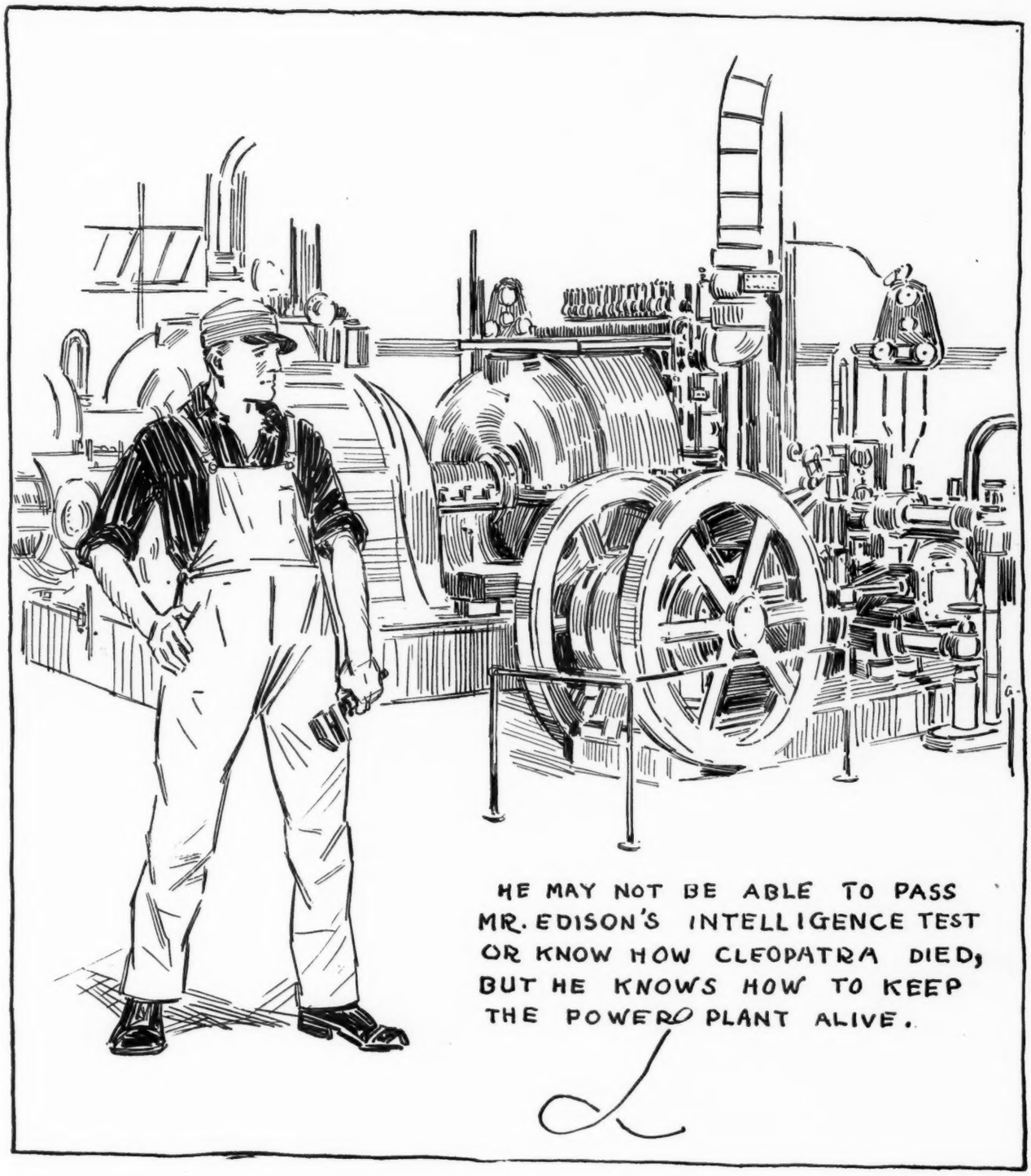
POWER

Volume 53 New York, June 14, 1921 *Number* 24


HE MAY NOT BE ABLE TO PASS
MR. EDISON'S INTELLIGENCE TEST
OR KNOW HOW CLEOPATRA DIED,
BUT HE KNOWS HOW TO KEEP
THE POWER PLANT ALIVE.

Changing a Hand-Fired to a Stoker-Fired Plant

By CHARLES T. MAIN*

Inefficient boilers, some 27 years old, and shortage of steam at times led to the decision to install new water-tube units and at the same time operate the old equipment in one of two boiler houses. This was done by building the new boiler-room floor 16 ft. 8 in. above the old boiler-room floor. Eventually, all the old units will be replaced by water-tube boilers on the same level as those recently installed.

IT IS RECOGNIZED by engineers that in the design of a power plant for mill purposes the chief opportunity of making savings is in the use of the by-products of power, such as exhaust steam and hot water, or in the operation of the boiler plant. As a cotton mill has but little use for the byproducts of power, there is left only the operation of the boiler plant wherein to strive for improved economy in the cost of power-plant operation.

In the eastern section of the country a common type of boiler for mill power-plant purposes has been the fire-tube type, either horizontal or vertical, in small units, hand-fired, fitted with no instruments for efficient combustion, operated usually at underrating, with cheap labor and at low efficiency.

Centralization of power, with increased size of units, high cost of boiler-room labor, results obtained in the steam stations of power companies, wherein 300 per cent normal rating or more is not uncommonly produced from the boilers, is having an effect upon the design of the mill power plant and leading to design and operation more in conformity to the modern public-service station.

It is of course true that, based on the rating of 10 sq.ft. of heating surface to a so-called boiler horsepower, the modern plant's first cost will be nearly double the old type of plant, but based on the actual output in boiler capacity obtained from each type of plant, the cost of plant per actual formerly designated boiler horsepower generated will not be found any more for the modern plant, with the cost of operation in the latter's favor. In the early part of the year 1920 the Utica Steam and Mohawk Valley Cotton Mills at Utica, N. Y., found that, largely due to overloading during the war period, the boiler plant at the Mohawk Division was in an inefficient condition. There was also during the colder months of the year a shortage of steam for power and heating purposes.

At that time the boiler plant at this division consisted of two boiler rooms, known as Nos. 1 and 2, placed at right angles and adjoining each other. (See Fig. 1.) Plant No. 1 contained five 72-in. horizontal return-tubular boilers with a combined heating surface of 8,500 sq.ft., and plant No. 2 contained four 72-in. and five 84-in. horizontal return-tubular boilers with a combined heating surface of 20,000 sq.ft. All were hand fired.

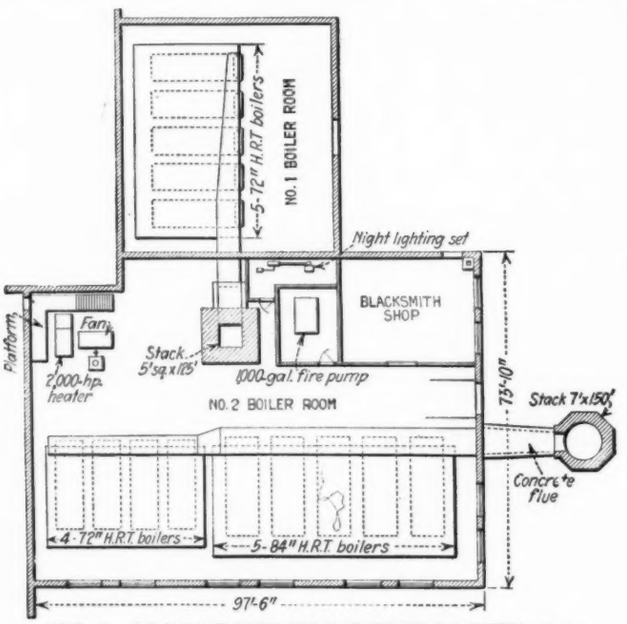


FIG. 1. PLAN OF THE TWO BOILER HOUSES, OLD ARRANGEMENT

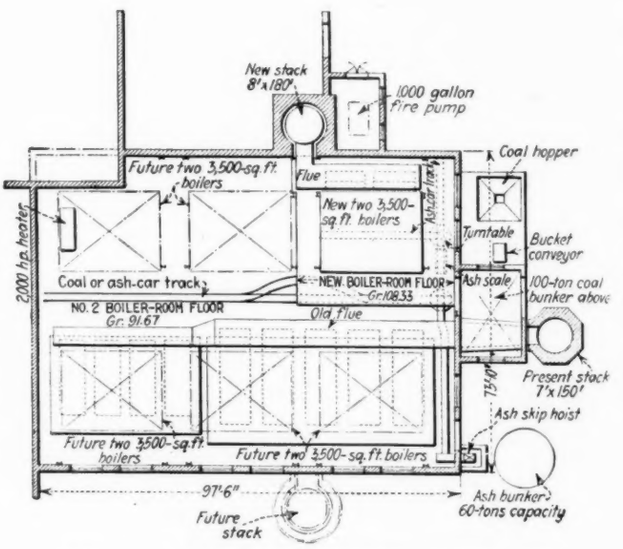


FIG. 2. PLAN OF NO. 2 BOILER HOUSE, NEW ARRANGEMENT

Undergrate draft for the boiler in each room was furnished by a fan common to both, and overgrate draft by a brick chimney for each boiler plant.

The boilers in the No. 1 boiler room were about 27 years old, and of those in No. 2 room, the 72-in. boilers were about 20 years old and the 84-in. boilers about three years old. Both boiler-room floors were at the same grade, about 2 ft. 6 in. below the yard level.

Coal was distributed from the railroad siding in the yard adjacent to the boiler houses by means of a flight conveyor. There was, however, no means of stocking out the coal, and a gang of men was employed to shovel the coal into wheelbarrows and wheel it into the boiler rooms, where it was dumped on the floor in front of the

*Consulting Engineer, Boston, Mass.

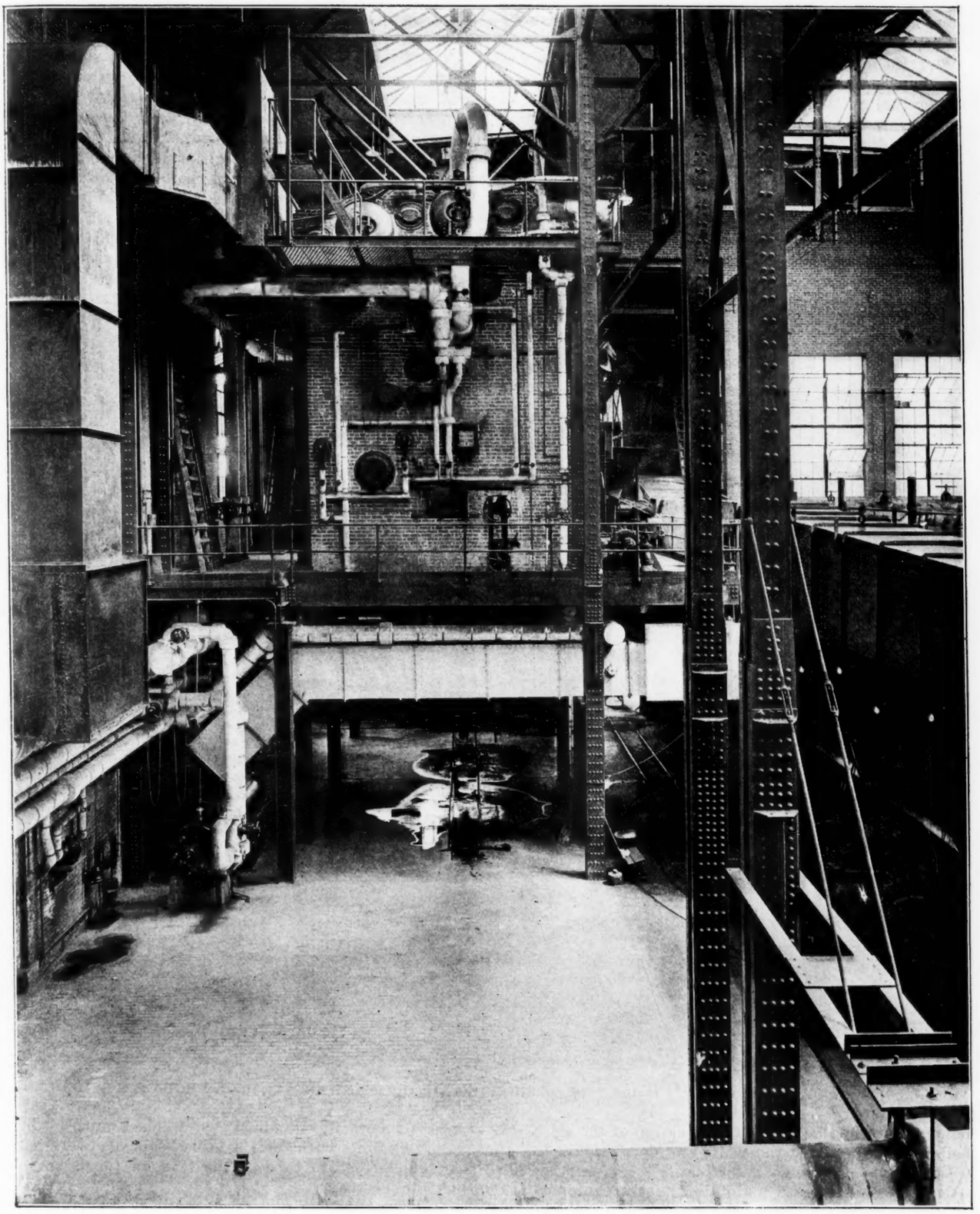


FIG. 3. GENERAL VIEW OF NO. 2 BOILER ROOM. OLD BOILERS AT RIGHT, NEW WATER-TUBE BOILERS IN CENTER, ELEVATED 16 FT. 8 IN. ABOVE THE BOILER-ROOM FLOOR

Eventually, twelve 3,500-sq.ft. boilers will be installed in No. 2 boiler room if the demands require. The two new boilers are operating at from 150 to 200 per cent rating. They are stoker-fired, the stokers being driven by a small steam turbine. The forced-draft fan is also turbine-driven. Ash hoppers are brick-lined and the ash gates are steam-operated. Ashes from the new boiler are dumped into ash cans, weighed and are then dumped into a skip hoist and are automatically deposited in an ash-storage bunker. A gasoline-driven tractor-crane, with a ½-ton grab bucket, removes coal from storage to the coal elevator hopper. Coal is drawn from the bunker into a motor-operated weighing larry, which deposits it in the stoker hopper of the new boilers or into a spout leading to the firing cars on the old boiler-room level, where it is hand-fired to the return-tubular boilers.

boilers. Ash was also removed by the iron wheelbarrows customarily found in hand-fired boiler plants.

An open-type feed-water heater fitted with V-notch meter furnished means of keeping account of the feed water used, but no means was provided for weighing either coal or ash.

After consideration of the condition of the plant, labor conditions, etc., it was decided that a new boiler plant should be started, which eventually would provide a boiler plant of modern design, especially in unit capacity and labor required for operation.

Space in the yard in the location where it was desirable that a new boiler plant should be built was limited. It was found by a study of the conditions that a new boiler plant could be built on the location of the old No. 2 boiler room, provided the work was done in stages. It was decided to pursue this method.

It was necessary to maintain the old equipment in operation until sufficient new equipment should be installed to replace that which was to be discontinued. It was also desirable that the 84-in. boilers should be continued in service for some years in order to derive the benefit of the investment already made in this equipment.

Owing to the fact that the company had derived excellent service from the water-tube boilers which were used in one of their other mill plants, it was decided that this would be the best type to adopt for their purpose, equipping them with underfed stokers.

The owners desired that the ultimate plant should be of sufficient capacity to take care of any growth of the mill that might occur for some years; also that each stage of the work should be in accordance with the carrying out of the ultimate plan.

The study of the final arrangement of the plant showed that twelve 3,500-sq.ft. boilers could be placed in the area bounded by the old No. 2 boiler-room walls; also that two of these units with a total of 7,000 sq.ft. of boiler surface could be installed at the first stage of the work by removing an underwriter's pump and using space temporarily occupied by a blacksmith's shop. These two units with their overload capacity were more than ample to take care of the load on the boilers in No. 1 boiler room.

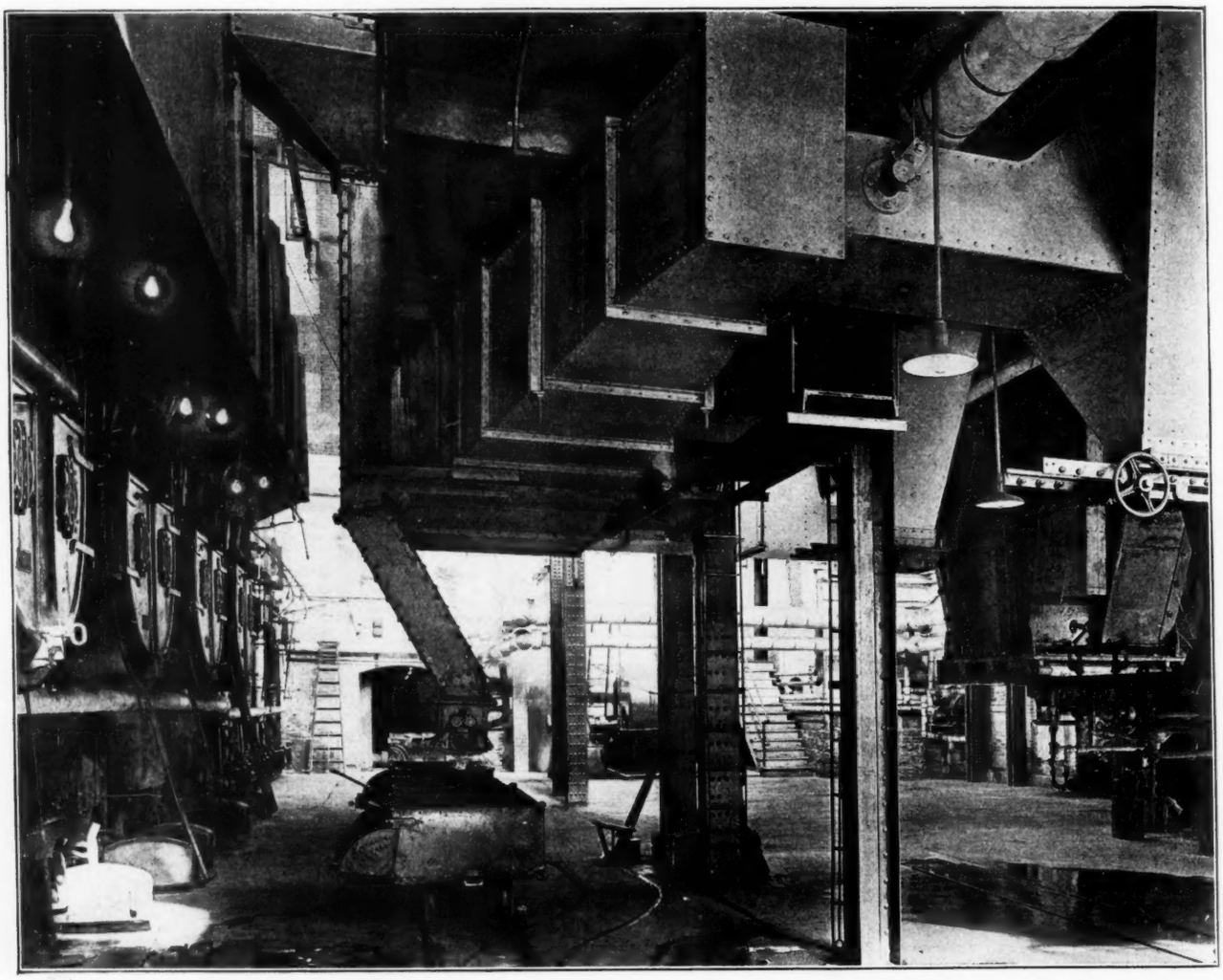


FIG. 4. OLD FLOOR LEVEL OF NO. 2 BOILER ROOM, SHOWING AIR DUCT AND ASHPIT DISCHARGE OF NEW BOILERS

With the underfed type of stoker it is important that convenient means shall be provided for the removal of ash which practically means that the modern boiler house shall be a two-story structure.

In this case, in order to continue the 84-in. boilers in operation, clearance should be provided for the removal of these boiler tubes.

The preceding requirements were satisfied by placing

the new boiler-room floor 16 ft. 8 in. above the old boiler-room floor. Reference to Fig. 2 will show the layout as planned and built.

At the present writing what may be called the first stage of the work has been completed. The two new boilers are in operation at from 150 to 200 per cent rating. No. 1 boiler room has been shut down and the chimney removed.

The new boiler house was built on the lines of the old No. 2 boiler room, and a new chimney 8 ft. by 180 ft. high was erected to serve the boilers on the north side of the house. Advantage was taken of the space between the east end of the boiler house and the existing chimney to erect a structure over which a 100-ton coal bunker is supported and into which structure the coal larry can run to receive its load of coal. Coal-crushing, elevating machinery and a 60-ton ash storage bunker were also placed at this end of the house.

The stokers used are of the underfed type driven by a small steam turbine The forced-draft fan is also turbine-driven. An interesting feature of the equipment is the ash hoppers, which receive the refuse from the grates. The outside of these hoppers is made up of cast-iron plates bolted to suspending angle irons and the inside is lined with brick. The ash gates are operated by a steam cylinder, which in turn is controlled by a four-way valve manipulated by the attendant. The design and operation of the hoppers and gates have apparently overcome many of the difficulties common to ash hoppers, such as cracking of cast-iron unjointed plates, corrosion of steel plates and the laborious work of opening and closing the gate by rack and pinion.

For the purpose of trimming the coal pile and moving coal from the pile to the coal-elevator hopper, a gasoline-driven tractor crane with ½-ton grab bucket has been provided. One man with this machine handles all the coal as far as the storage bunker. The man operating the two new boilers draws the coal from the storage bunker into a motor-operated weighing larry, weighs and deposits it in the stoker hoppers or in the spout leading to the firing cars on the industrial track at the old boiler-room floor level. The coal is hand-fired from these cars to the return-tubular boilers.

The old stack occupying the space required for the second battery of new boilers having been removed, the next step in the progress of the work will be the extension of the new boiler-house floor, the addition of the new second battery of boilers and the installation of a duplicate stoker drive and forced-draft fan, after which another batch of the old boiler will be removed. Should the demands for steam require it, this method can be pursued until the entire house is filled with boilers, with a total of 42,000 sq.ft. of heating surface and an actual output, if necessary, equal to at least 50 per cent more.

Recognizing the fact that the efficient and economical operation of a boiler plant for a mill as well as for a central station is based on brains rather than brawn, the plant has been fitted with all the necessary instruments, control apparatus and equipment for intelligent operation and labor saving.

The equipment installed has thus far shown a saving in cost of labor of 40 per cent and a saving in coal per week from 12 to 14 per cent.

The entire first stage of the work was carried out and the boilers put into service in less than four months, notwithstanding the fact that space available for storage of materials was very limited, the old plant had to be kept in operation, and most of the work was during the winter months.

The engineering work was done by Charles T. Main, Boston, Mass., and the construction work by Stone & Webster, Inc., Boston, Mass.

PRINCIPAL EQUIPMENT OF NEW BOILER PLANT, UTICA STEAM AND MOHAWK VALLEY COTTON MILLS

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
2	Boilers	Stirling	3,500 sq.ft. heating surface	Steam generators	Stoker-fired	Babcock & Wilcox Co.
2	Soot blowers	Diamond		Blowing boiler tubes	Steam	Diamond Power Specialty Co.
2	Stokers	Underfeed		With boilers	Turbine-driven, forced draft	Sanford Riley Stoker Co.
2	Ash hopper	Brick-lined		With boilers	Ash gates steam-operated	Baker-Dunbar-Allen Co.
1	Track and scale	Industrial		Coal and ash	Hand ash and coal car	C. W. Hunt Co.
1	Pump	Turbo		Boiler feed	Turbine-driven	Terry Steam Turbine Co.
2	Regulator	Balanced-draft		Regulate furnace draft		The Engineer Co.
1	Tractor crane	Gasoline	½-ton bucket	Coal-handling	Gasoline engine	Pawling & Harnischfeger Co.
1	Chimney	Brick	8 ft. dia., 180 ft. high	Furnace gas		M. M. Kellogg Co.

Coal- and ash-handling equipment, Colwell, McMullin Co.; Stephenson Adamson Co.; superstructure, Stone & Webster Const. Co.; structural steel and galleries, Utica Steam Engine and Boiler Works.

Lubrication Specifications for High Pressure Compressors

The Diesel Engine Users Association of England recommend that lubricating oil for use in Diesel air compressors should meet the following specifications:

(a) The oil should be entirely free from suspended particles of water.

(b) The oil must be entirely free from sand or other inorganic material. No mechanical impurities must be visible in the oil when it is viewed by holding a sample in a glass vessel against a light.

(c) The oil must be entirely free from inorganic acids.

(d) Oils should not be lower in viscosity than 385 seconds Saybolt nor higher in viscosity than 700 seconds Saybolt at 70 deg. F.

(e) Oils, when tested in closed cup, should in no case be lower in flash point than 350 deg. F.

(f) If the oil is to be used on an inclosed-crankcase high-speed engine in which the same lubricant is used both for the compressor and in the crankcase, it should have a closed-cup flash point of not less than 400 deg. F. (It should be borne in mind that "Open" flash point tests give results 20 deg. to 30 deg. F. higher than the closed tests on these types of oils.)

For further guidance it may be pointed out that from past experience it has been found that the oils that have met with most success in Diesel-engine air-compressor lubrication have generally possessed properties lying within the following limits:

Specific gravity	0.870 to 0.915 at 15 deg. C.
Viscosity (Saybolt)	500 to 1,200 seconds at 70 deg. F.
Viscosity (Saybolt)	85 to 160 seconds at 140 deg. F.
Closed flash point	Not less than 400 deg. F.
Color	Red or yellow by transmitted light, but clear. (Not misty or smoky.)

Both straight mineral oils and compounded oils containing small quantities of saponifiable oil have met with success on Diesel-engine compressor service, but the majority of successful oils have been straight mineral oils.

Improving a Refrigerating Plant

By J. C. MORAN

A MAN who had been in the ice-cream business involving the use of refrigerating machinery in a Northern state sold out and went South to engage in the same line. He figured to double his old production and so installed a refrigerating plant of twice the capacity of his old one. When the plant started, he found to his surprise that he could produce only from 10 to 20 per cent more than he did in the old plant. He first blamed it on the power-plant crew and discharged a number of engineers without helping matters at all. In fact, some of them could not get as much capacity out of the new plant as was obtained from the old one. He even had the chief engineer of the old plant come down and look the place over, and he failed to discover anything that would account for this condition of affairs.

There was plenty of business to be had, but the owner had sunk practically all his available funds in the plant and it was out of the question to add more machinery at this time, besides being an expensive way of getting results. A number of refrigerating engineers and experts had been sent out from the home offices of the manufacturers of the different kinds of equipment, and none of them had been able to locate anything wrong with the installation.

The Writer Offers His Services

I happened to be in this city about that time, making a little change in another refrigerating plant, and hearing of the trouble they were having, I offered to take a look around, which was gladly accepted, although the owner informed me that he did not believe that I would be able to find anything because they had had about a dozen different experts on the job already and none of them had been able to remedy the trouble.

After looking the factory over without finding anything wrong in the way the machinery was handled, I got the dimensions of the various ice machines and other equipment and figured up the load on the machines at the present output and their proper load if they were operated according to the best practice. I had had occasion to solve a few similar troubles a short time before this, although these were only minor matters, but they had given me a general knowledge of the business and approximately about how much equipment was required for a given output. After figuring the problem from all possible angles, I finally had to admit that the plant was amply large to manufacture the 2,000 gal. of finished product (1,000 gal. of mix) that was required. Generally, from 20 to 25 tons of refrigerating capacity is required per 1,000 gal. of raw product or *mix* handled, depending to a certain extent on the length of the working day; that is, 8, 9 or 10 hours. This is the actual amount of refrigeration required to cool the cream after pasteurization, to hold it at a fairly uniform low temperature for 24 to 48 hours after pasteurization, and finally to freeze and harden it. This does not take into consideration the refrigeration required to take care of the heat losses in the milk-storage room and in the hardening rooms, where the cream is hardened after it has been frozen in the freezers on the machine floor.

The latter problem is, of course, a simple matter of figuring the heat losses through the walls of the hardening rooms. Allowances must also be made for opening and closing of doors and the presence of persons and lights, etc., in the rooms for any length of time, which is exactly the same problem as in cold-storage work or anything of a similar kind.

There were no figures on hand for checking; however, after figuring everything liberally, I was surprised to find that not over 75 tons capacity should be required, while the total capacity of all the machines was about 85 tons. I was somewhat at a loss, after checking my figures over and over again, to account for the fact that they were unable to get much more than half the required output with this liberal capacity.

Not being able to discover anything by this method, I next began to cross-examine the engineers as to where they were having the most trouble. There were a number of these, but the greatest trouble seemed to be that they were unable to cool the mix down to the proper temperature after pasteurizing, and also that they were unable to keep the temperature of the calcium brine, which was used for the freezers, low enough for fast work. This same brine was also used for the pasteurized mix cooler, and this looked like a promising place to begin searching for the root of the trouble.

The operators were inclined to blame their troubles on the double-pipe brine cooler which cooled the calcium brine for this service. In the old plant up North a common brine tank had been used and had served the purpose with satisfaction. The man who had sold the refrigerating machines, however, had persuaded the owner to buy the cooler.

The Required Refrigeration Capacity

A rough estimate proved that approximately 160 gal. of brine had to be supplied per minute in order to give the desired output from the freezers and the pasteurized-milk cooler. The brine cooler was made up of a single stand, 12 pipes high and 18 ft. long with a total length of pipe of approximately 225 ft. In addition there was approximately 75 ft. of 2-in. discharge line, which was the same size as the inner pipe of the brine cooler, the outside pipe being 3-in. This made a total of about 300 ft. of 2-in. pipe through which the 160 gal. of brine had to travel. This would give a friction drop of approximately 30 lb. per 100 ft., or 90 lb. for the entire run. This, with the addition of a static head of about 10 lb. and a friction loss of 5 lb. due to the number of elbows and tees in the line, made a total pressure head of around 105 pounds.

Evidently, the man who designed the plant had very little experience with double-pipe brine coolers and he could not have done much figuring on the friction loss in the pipes, because a 200-gal. centrifugal pump, rated at 75 ft. head at full load, had been installed. This was about one-third of the pressure required with 160 gal. delivery, and as a consequence the amount of brine actually delivered was not only insufficient for the freezers and the mix cooler, but it also slowed down the flow through the brine cooler and thus reduced cooler capacity to a large extent, the capacity of a double-pipe brine cooler being greatly affected by the velocity at which the brine flows through it. The net result was that there was a pressure of about 8 lb. on the discharge header at

the ice-cream freezers, instead of between 15 and 20 lb.. as was recommended by the manufacturer who supplied the machines.

This was only part of the trouble. The Baudelot cooler for cooling the pasteurized mix was located on the floor above and was about ten feet above the header to the cream freezers. It will be seen that there was left only about three or four pounds available for feeding brine to the Baudelot cooler.

Fig. 1 illustrates the construction of the Baudelot cooler. The brine section consisted of 6 pipes and there were two sections of water-cooled pipe of 6 pipes each, making a total of 18 pipes. These pipes were approximately 1¼ in. inside diameter, and the pipe connecting with the header below was 1¼ in., about 30 ft. long.

Assuming a five-degree temperature rise of the brine, this cooler required about 30 gal. of brine per minute when in operation. Considering the small pressure available, the ten- or twelve-foot static head, the number of right-angled turns in the cooler and a number of short-turn elbows in the pipe connecting the header below with the cooler, it will readily be seen that the pressure available was entirely insufficient.

The water for the water sections of the cooler was taken from a cooling tower and seldom came below 85 deg. and often went up to 100 deg. during hot, humid weather. As a consequence the pasteurized cream came off the water section somewhere between 90 and 100 deg. and therefore the brine section, with the poor circulation, was not able to bring it down to the proper temperature.

To help matters out, they had attempted to finish the cooling of the pasteurized cream in the holding tanks. These are built somewhat on the principle of a vacuum bottle, with an air space between the inside and the outside shell. A header was provided on each tank so that steam or brine could be sprayed into this space in

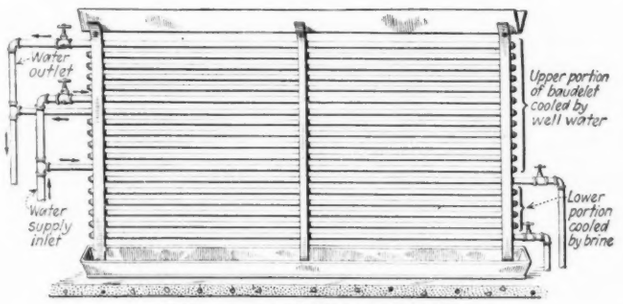


FIG. 1. BAUDELOT COOLER

case it was desired to heat or refrigerate the cream while held in the tanks.

If a vacuum of 15 to 20 in. is pumped on these tanks, they will hold the cream at a fairly uniform temperature, there being practically only from 2 to 5 deg. rise by the time it is desired to remove the cream, unless the temperature in the room is extremely high. As a consequence these tanks are not insulated, the air space between the two shells serving this purpose.

When brine was turned into this space, an entirely different condition was the result. The brine spattered against the outside shell as well as the inside shell of the tank, and as this was exposed to the temperature of the room, a large amount of heat was taken up in this manner by the brine, which was a total loss, simply helping to keep down the temperature of the room, which generally had all the windows and doors open. This put a large amount of extra load on the brine cooler and the machine operating on it, with the result that a large amount of work represented a total waste.

A compressor of approximately 20 tons nominal rating was operating on the brine cooler at about zero suction pressure, which reduced its actual capacity to about 10 tons. Furthermore, we found later that one of the discharge valves had a piece cracked out of it, which had reduced its capacity still more.

The rest of the installation was liberal. An 8-ton machine was used for the hardening rooms exclusively,

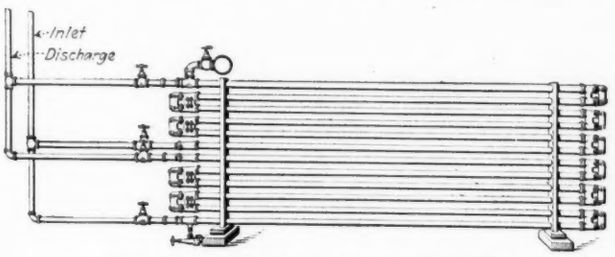


FIG. 2. CHANGE IN BRINE COOLER

and as the hardening room was heavily piped, no trouble was experienced in that quarter.

A 55-ton machine had been provided for the ice tank, the rated capacity of the tank being 35 tons. The idea, in installing this large tank capacity, was to take care of further increases in the plant business, as well as to supply ice in case there was capacity to spare; so far they had sold more ice than they had been able to use in their own business.

Change in the Brine Cooler

My first move was to split up the brine cooler into two parallel sections. This cut the velocity through the cooler in half and also shortened the length of travel through the cooler in two, thus reducing the total length of the travel over 100 ft. As the friction head varies with the square of the velocity, it will be seen that this reduced the friction through the cooler to one-quarter of what it had been, or nearly so, and by cutting the length of the travel in two, the friction head was finally reduced to approximately one-seventh or one-eighth of what it was before.

Our next move was to install a new 3-in. discharge line from the brine cooler to the header above the freezers. All the work had been arranged so that the change over to the new arrangement was done on a Sunday. During this time the compressor was also opened up and the leaky discharge valve discovered and promptly exchanged for a new one. We also changed the supply brine line from the brine header in the freezer room to the Baudelot mix cooler above, to a 2-in. line and ran it practically straight up from the header with a single long-radius bend in it.

Monday morning things went humming from the start. Where before the best they could do was to hold the brine at about 12 deg. and an 8- to 10-deg. rise between the incoming and outgoing brine, they now were able to hold at one to two degrees above zero and with a rise of from two to four degrees between the incoming and outgoing brine—with a suction pressure of about ten pounds. The owner was tickled, to say the least, and so was the rest of the organization. It evidently put new pep into the business because at the end of two weeks they were securing from 10 to 25 per cent more than the machine rating of the plant.

Effect of Preheat and Excess Air on Combustion of Fuel

By A. D. WILLIAMS

HEAT is generally described as the energy of the moving molecules of a substance. Its intensity is measured by the thermometer. Its quantity is measured by the British thermal unit. Heat transfer takes place by conduction, convection or radiation and will take place whenever a temperature difference exists. The quantity of heat stored in a unit of fuel may be determined by the calorimeter or computed from the chemical composition of the fuel. But the amount of heat stored up within the fuel does not supply any index in regard to the temperature difference that may be established by its combustion or to the amount of heat given up to another substance.

Combustion is the oxidation of fuel and results in the releasing of the latent heat and the establishing of a temperature difference, or head, which permits utilization of the heat in useful service. The losses that occur in combustion are small and comparatively unimportant in view of the enormous losses that occur in the application and utilization of the heat released. Since fuel costs are continually advancing, consideration must be given to the possibility of substituting one fuel for another or of introducing methods of operation and new apparatus that will accomplish the same result at a lower cost.

Comparison of the relative values of different fuels for any given purpose involves many factors, any one of which may have a considerable effect. There are many tables giving the thermal values of fuels as determined by the calorimeter or by computations. However, the temperature obtainable by the use of any particular source of heat energy depends upon so many variables that it cannot be reduced to a tabular form. Experiment and practice have developed a certain amount of knowledge regarding the temperatures obtainable, but this supplies an uncertain guide regarding the temperature effects that may be expected under different conditions.

The temperatures obtainable by the combustion of a substance depend upon: (A) The quantity of heat released by the combustion of a unit of fuel; (B) the

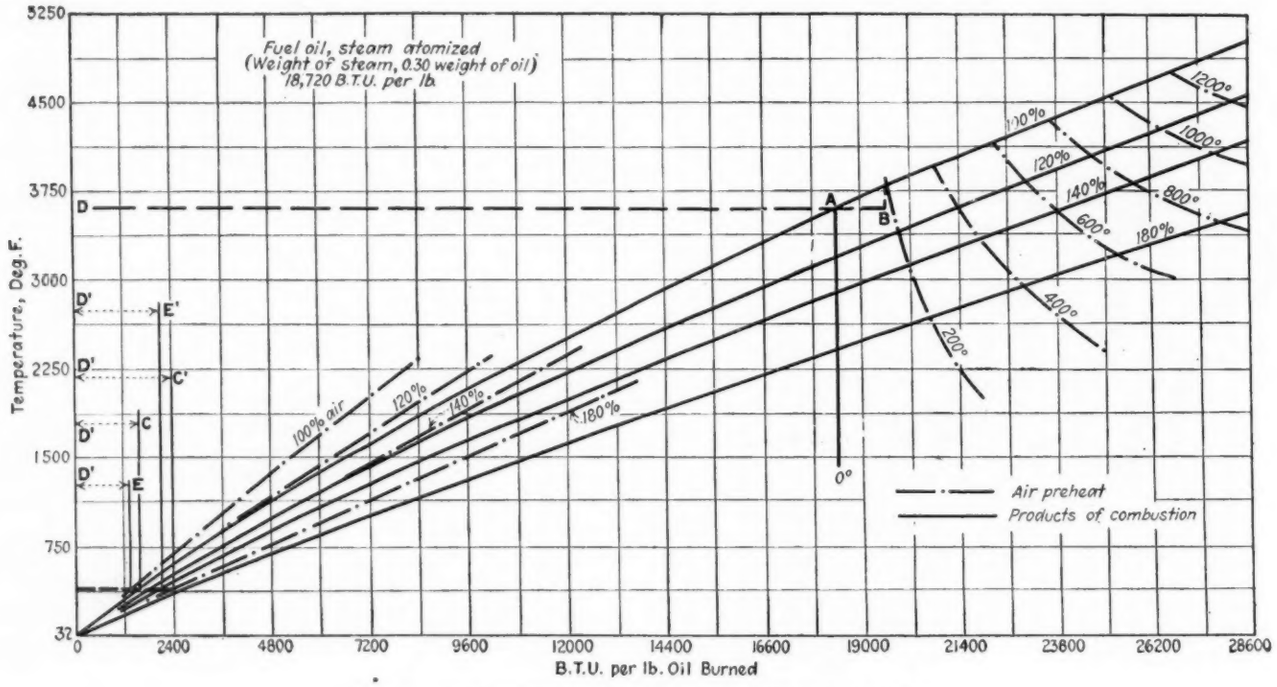


FIG. 1. COMBUSTION OF FUEL OIL, STEAM-ATOMIZED

oxygen supply or the amount of air used; (C) the temperature of the fuel and air supply at the point of combination; (D) the heat capacity of the products of combustion; (E) the velocity of the reaction of combustion; (F) the shape and volume of the combustion furnace; (G) the completeness of combustion.

A is readily obtainable. B and C are susceptible of control and in turn bring D under control. The problem may be solved by making certain assumptions regarding the other variables. These assumptions are: (1) That complete, instantaneous combustion occurs; (2) that the total amount of heat released is contained in the products of combustion, that is, that combustion occurs in a thermal chamber which does not absorb or give off heat.

It is impossible to realize either of these assumptions in practice, but they permit the computation and plotting of curves which supply a large amount of *relative* information regarding the temperature possi-

bilities of a combustible under a variety of conditions. True, the values are only approximate and the assumed conditions are impossible, but at the same time these curves permit a very close approximation of the results obtained in practice and show the effect of variations in operating conditions upon the temperature realized.

The curves in Figs. 1 to 3 show the potential possibilities as regards heat transfer of pulverized coal and oil fuel when burned with various amounts of excess air and various amounts of preheat for the air and fuel, when this latter does not contain hydrocarbons dissociated by preheating. One of the interesting facts revealed by a study of the charts is that the use of steam instead of air for atomizing oil results in reducing the temperature obtainable by 305 deg. F. This is due to the fact that the same amount of air is

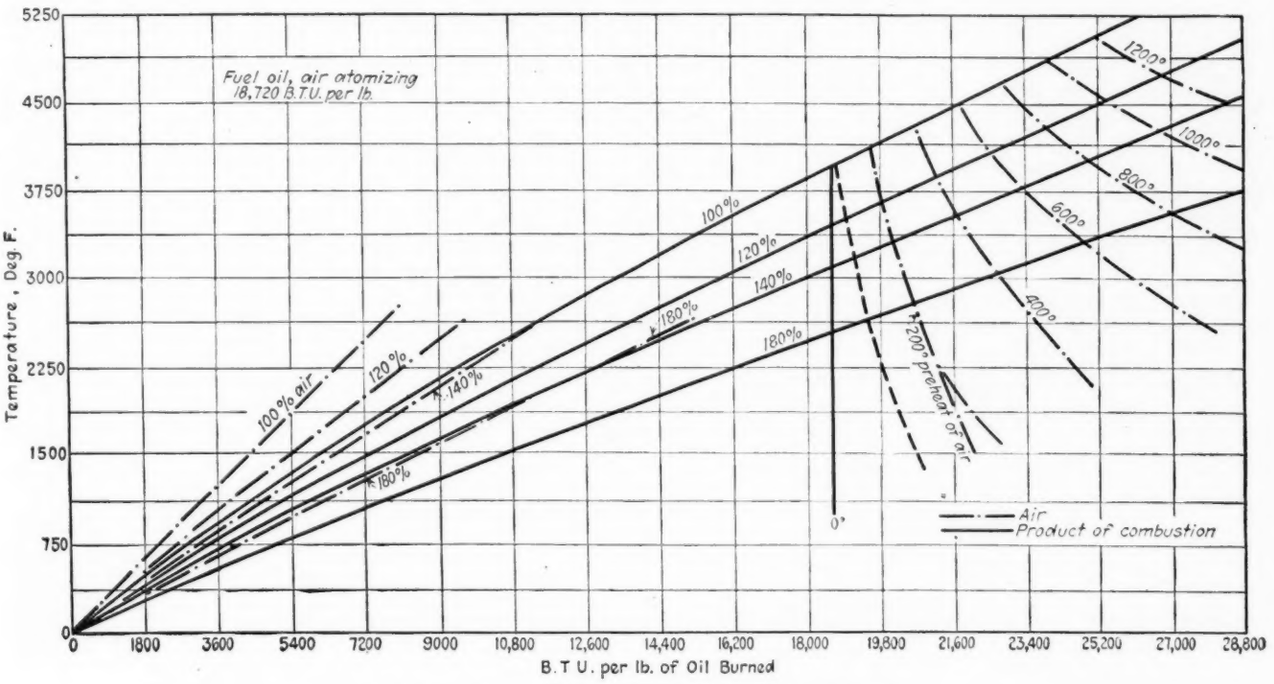


FIG. 2. COMBUSTION OF FUEL OIL, AIR-ATOMIZED

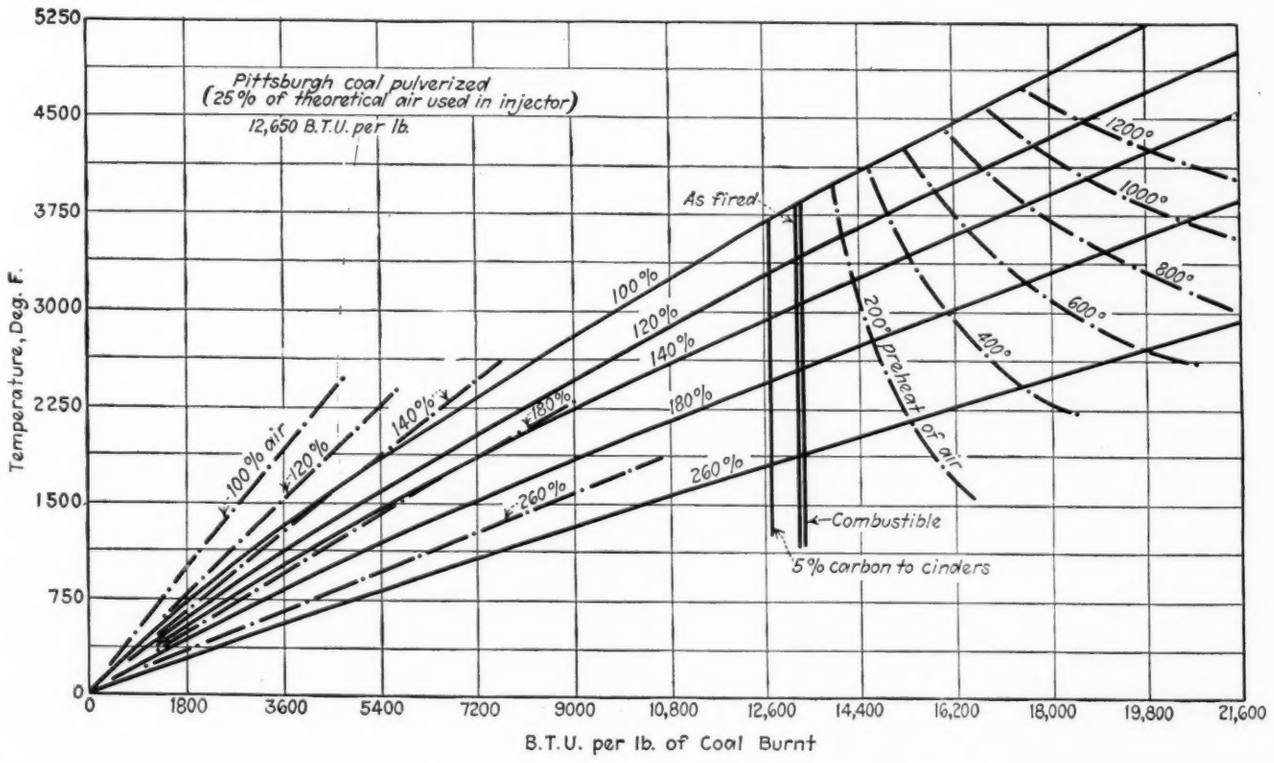


FIG. 3. COMBUSTION OF PULVERIZED COAL

required in both cases and the steam merely increases the volume and weight of the products of combustion —in other words, excess baggage. At the same time it may be more economical to use the steam directly in the atomizing instead of indirectly in compressing the air for atomizing.

In a marine installation where space and weight have to be considered, a Great Lakes boat floating in her boiler-feed supply could well use a steam jet. On salt water, where boiler makeup is obtained by evaporation, an air-compressor engine would exhaust into the condensers, thereby reducing the evaporator capacity, or the air-blast fans could be run by motors. Steam jets would increase evaporator capacity and heat consumption. A mechanical atomizer would eliminate the objections to both these systems but require high-pressure pumps. Assuming a 20 per cent excess air supply, a comparison made from the curves shows that the loss due to the use of steam for jetting is about 1 per cent. This is 1 per cent of the heat released and available for producing steam at boiler efficiency. A further loss of from 1 per cent to 9 per cent of the steam generated occurs by using steam in atomizing. With air atomization the temperature in the firebox will approximate 3,280 deg. F. and with steam 3,110 deg. F. The actual temperature realized will be about 200 deg. F. lower, owing to the firebox construction. In fact, much lower temperatures may be obtained under unfavorable conditions.

EFFECT OF EXCESS AIR ON A BOILER AND ECONOMIZER AT VARIOUS LOADINGS

	50 per Cent Load	100 per Cent Load	150 per Cent Load
Coal burned per hour, lb	1,808	3,352	4,916
Air supply, per cent	260	180	140
Products of combustion per unit of fuel, cu.ft.	334	233	183
Air supply per unit, cu.ft	328	227	177
Initial temperature in boiler, deg. F	1,832	2,480	2,957
Final temperature in boiler, deg. F	518	617	716
Initial temperature in economizer, deg. F	518	617	716
Final temperature in economizer, deg. F	275	410	527
Drop in temperature in boiler, deg. F	1,314	1,8 3	2,241
Drop in temperature in economizer, deg. F	243	217	184
Heat per unit of fuel at above temperatures from curve, initial B.t.u.	13,260	13,260	13,260
Heat in gases leaving boiler, B.t.u.	3,420	2,646	2,394
Heat in gases leaving economizer, B.t.u.	1,494	1,620	1,620
Heat available in boiler, B.t.u.	9,840	10,614	10,866
Heat available in economizer B.t.u.	1,926	1,026	774
Total heat available in boiler, B.t.u.	17,790,000	35,583,000	53,420,000
Total heat available in economizer, B.t.u.	3,482,000	3,439,000	3,805,000
Total heat in gases at base of stack	2,699,000	5,431,000	7,964,000

While these charts can be used to determine many of the factors of combustion, their particular advantage lies in the calculations for the results obtained by the use of excess air and by preheating the air supply.

Assuming that fuel oil, steam-atomized, is under investigation, the heat evolved with 100 per cent air is the line *AD*, in Fig. 1, or 18,720 B.t.u.; and if the gases escape through the uptake at 400 deg., the heat available in the furnace is *AD–CD'*, or 17,200 B.t.u. Part of this is used to heat the air supply, this being *D'E*, or 1,300 B.t.u., leaving 15,900 B.t.u. to be absorbed by the boiler. With 180 per cent air supply the heat released is the same. With the same stock temperatures the heat lost is *D'C'* or 2,400 B.t.u. The heat required to heat the air is *D'E'*. If the air is preheated to 200 deg. F., the heat of combustion is *DA* + *BA*, with the air supply taken at 100 per cent. From this it appears that preheating is advantageous and excess air, theoretically at least, is detrimental.

With the temperature of the gases leaving the boiler at about 500 deg. F., an improvement in combustion conditions by reducing the air supply will increase the furnace temperature realized as well as the amount of heat available. The increase in furnace temperature increases the temperature differential between the products of combustion and the water in the boiler, giving a direct increase in the rate of heat transmission through the boiler-heating surface. The effect of such changes can be readily approximated from the curves. However, a study of these curves will show that increasing the heat-absorbing capacity of the boiler and utilizing more of the heat rendered available by the burning fuel will secure greater fuel economy than can be attained by improving combustion, in most cases. Presumably, this is heresy, but there will be 16⅔ per cent improvement by increasing the evaporation one-sixth, while the amount of heat rendered available by cutting down the excess air will be only the amount carried up the stack by that excess air. This is a potent argument for the keeping of both the inside and the outside of the heating surfaces clean.

The table shows the application of the data found in these curves and tables to the specific case of a 5,000 sq.ft. boiler operated at 50 per cent, 100 per cent and 150 per cent of its rated capacity, assuming that pulverized coal is used.

Sustained Efficiency of Diesel Engines

When a power plant contemplates the installation of new units, one of the most pertinent questions raised is that of the sustained efficiency of the new machinery. Under shop engineers are often obtained results that cannot be duplicated by the ordinary operating force. Frequently, power plants show, for the first year's operation, economies that far exceed those obtained in subsequent years. It is natural to expect machines to show a decreasing efficiency year by year.

Certain types of prime movers, including internal-combustion engines, have an efficiency that is fairly maintained throughout their useful life. As long as ordinary attention is given to keeping the machine up, no great increase in power costs will be experienced. In the accompanying table appear the results of tests on three Diesel engines A, B and C, which are located in the same power plant. As shown, engine A was manufactured in 1916, engine B in 1917, while engine C was manufactured in 1910 and in 1911 delivered a kilowatt-hour at an expenditure of 0.69 lb. of fuel.

A striking result of the test made this year on the three units is the uniformity of the thermal efficiency of all three engines, the variation in B.t.u. per kilowatt-hour being only 1,416. The most remarkable feature is the high efficiency of the C engine, which, after 10 years of service, has a fuel consumption within 3 per cent of the B engine. It is usually considered that the more modern designs are superior to the early types of Diesels. This test nevertheless proves quite conclusively that the efficiency of the Diesel is directly traceable to the cycle of operation and refinements in design improve the fuel consumption but slightly.

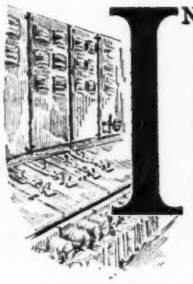
RESULTS OF TESTS ON THREE DIESEL ENGINES

Engine	A	B	C	
Horsepower	500	500	225	
Year manufactured	1916	1917	1910	
Year tested	1921	1921	1921	1911
Temperature cooling-water inlet	80	82	80	.....
Temperature cooling-water outlet	126	130	126	.....
Oil consumed, pounds	20,556	21,071	11,970	.....
Kilowatt-hour output	30,970	29,050	16,090	.....
Length of test, hours	100	100	100	1
Load factor, per cent	86	90	90	100
Pounds fuel per kilowatt-hour	0.66	0.72	0.74	0.69
Kilowatt-hours per barrel fuel	476	436	425	455
B.t.u. per kilowatt-hour	12,478	13,636	13,994	13,045
Fuel cost per kilowatt-hour, mills ($3.23 per bbl.)	6.60	7.41	7.10	.....

Switchboard-Meter Connections—Three-Phase Circuits

Wattmeter and Watt-Hour Meter Connections on Three-Wire and Four-Wire Circuits—Power Consumption of Instruments

BY E. A. REINMAN



IN THREE-PHASE work it is not always sufficient to know the instantaneous polarity; the phase relations and rotation of phases must often be considered. In tracing out wiring diagrams, however, it is sufficient to assume the polarity at one instant, and the conditions generally chosen are shown in Fig. 1, where the current is flowing out through the two outside wires and back through the middle one. If the system be a three-phase four-wire, the direction of current in the neutral is considered the same as in the middle wire. Some prefer to consider the current as flowing the same way through the three-phase wires and back through the neutral.

For a simple current measurement on a three-phase three-wire circuit, only two ammeters are necessary, although three are generally used for convenience; one ammeter may also be used with an ammeter switch. In both cases the polarity need not be known. A three-phase four-wire circuit requires three ammeters or a multi-circuit switch to place the ammeter in any one of the three wires. One voltmeter is usually employed for voltage measurements, but it may be provided with a voltmeter switch of the plug-and-receptacle or revolving-drum type, to change from one phase to the other or from one circuit to another by means of the voltmeter bus, as described under two-phase work in a previous issue.[1]

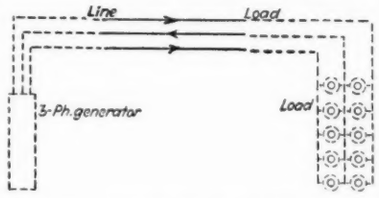


FIG. 1. ASSUMED CURRENT FLOW IN 3-PHASE CIRCUITS

In a simple three-wire three-phase system the power may be accurately measured by means of two single-phase or one polyphase wattmeter or watt-hour meter. The connections of two single-phase meters without transformers are shown in Fig. 2 and with transformers in Fig. 5. While this connection gives accurate readings on balanced or unbalanced load at any power factor and is interesting in that the power factor of the system may be determined from the ratio of the two meter readings, it is seldom employed. It is not convenient in practical work to add two meter readings in order to know the load, particularly as one meter will run more slowly than the other when the power factor is less than 100 per cent, and will reverse below 50 per cent.

[1] *Power*, April 12, 1921, page 576.

The polyphase meter is the most convenient instrument to use on a three-phase three-wire circuit, as it indicates directly the true power, regardless of unbalancing of load or variations in voltage or power factor. The connections of a three-phase three-wire wattmeter are shown in Fig. 3 without instrument transformers and in Fig. 4 with transformers. There are several kinds of meters available with from five to eight terminals, accommodating any combination of current and potential transformers.

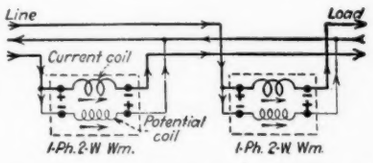


FIG. 2. MEASURING POWER IN 3-PHASE 3-WIRE CIRCUIT WITH TWO SINGLE-PHASE WATTMETERS

Polarity and correct phasing are most important in a polyphase meter on a three-phase circuit. There are a great number of connections that will give an incorrect registration, but only one correct connection; and the chances of error are numerous, particularly as some of the faulty connections under certain conditions give indications that are almost identical with those of the correct connection. To avoid mistakes, the use of seven-conductor multi-colored cable is strongly recommended, as it represents the practice of some of the best stations in the country.

When the correct connection has once been secured, it is important to avoid disconnecting the instrument, so as to eliminate chances of error in reconnecting. Inasmuch as all meters should be subjected to periodic tests, it is advisable to provide switching facilities for connecting them to a testing circuit without removing the main-circuit connections. Double-throw transfer switches may be conveniently used for this purpose. In this way a first-class meter man may be engaged to make the correct initial connections, and the periodic checking may be intrusted to a less experienced man with the assurance that connections will not be interchanged. The use of a seven-pole combination of double-throw switches applied to a three-phase three-wire sys-

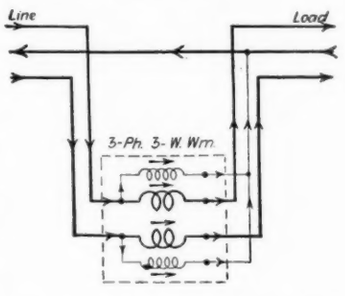


FIG. 3. POLYPHASE-WATTMETER CONNECTIONS ON 3-PHASE 3-WIRE CIRCUITS

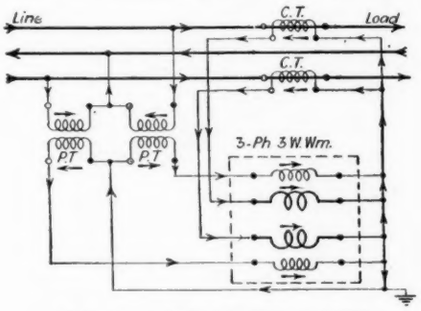


FIG. 4. SAME AS FIG. 3 WITH CURRENT AND POTENTIAL TRANSFORMERS

tem is shown in Fig. 7, where the meter is connected to the transformers· in Fig. 8 the meter is connected to the standard or "test" circuit, ready for testing. The arrowheads represent the direction of the current in both cases. Those switches to which the current transformers are connected should be designed to close the circuit on one side before they break it on the other. Fig. 11 illustrates one type of switch used for this purpose. They should also be double-pole switches, to avoid any chance of the transformer secondaries being opened at any time. The potential transformer switches

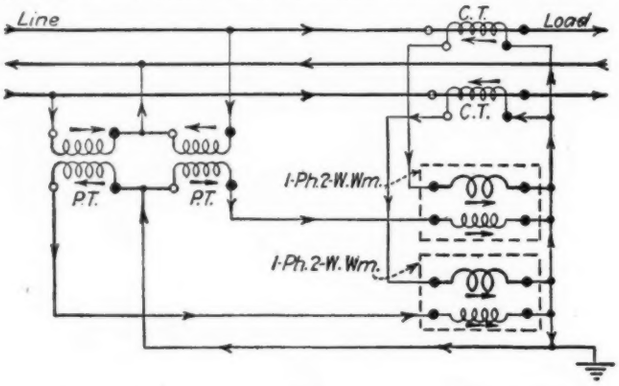


FIG. 5. MEASURING POWER IN A 3-PHASE 3-WIRE CIRCUIT WITH 2 SINGLE-PHASE WATTMETERS AND CURRENT AND POTENTIAL TRANSFORMERS

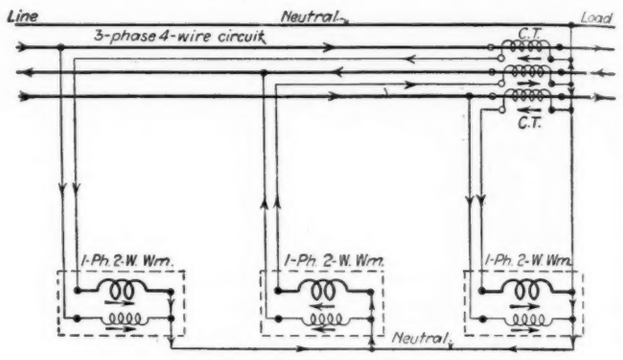


FIG. 6. MEASURING POWER IN A LOW-TENSION 3-PHASE 4-WIRE CIRCUIT WITH THREE SINGLE-PHASE WATTMETERS

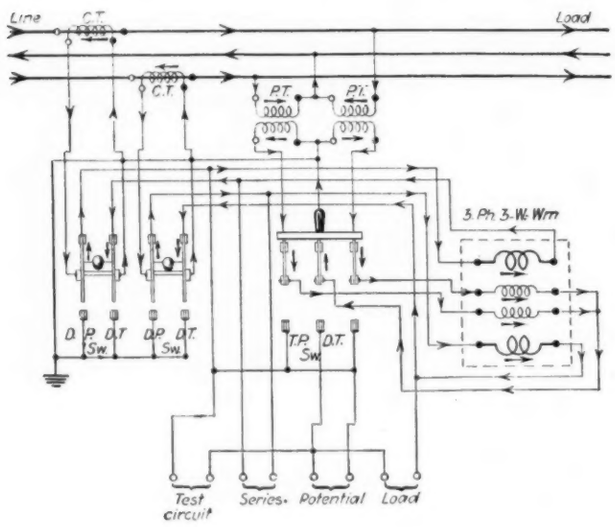


FIG. 7. THREE-PHASE 3-WIRE SWITCHBOARD CONNECTIONS FOR POLYPHASE WATTMETER AND TESTING CIRCUIT—WATTMETER CONNECTED TO 3-PHASE LINE

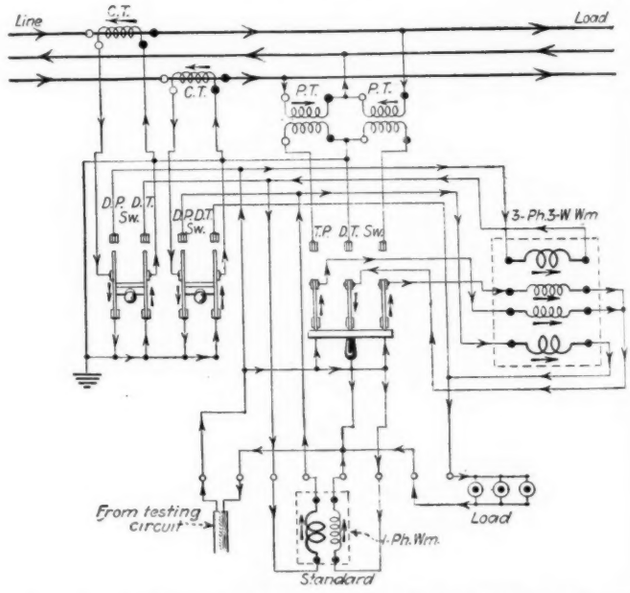


FIG. 8. THREE-PHASE 3-WIRE SWITCHBOARD CONNECTIONS FOR POLYPHASE WATTMETER AND TESTING CIRCUIT—WATTMETER CONNECTED TO TESTING CIRCUIT

should be ordinary double-throw knife switches, which break one circuit before they close the other. A triple-pole switch may be used for the potential transformer circuits on three-phase three-wire circuits.

Three-Phase Four-Wire Systems

Under three-phase four-wire systems come all three-phase circuits grounded at both ends, for the ground replaces the fourth wire. Were the three-phase four-wire system always balanced, it could be metered like a three-phase three-wire system; but it is seldom so, and therefore requires special methods of metering. Power may be correctly measured in a three-phase four-wire circuit under all conditions, by any one of three methods, which are in fact theoretically identical: First, by means of three single-phase wattmeters with current coils connected in each phase wire and potential coils between this wire and the neutral as shown in Fig. 6. The connections shown in Fig. 6 are for low-voltage circuits, and potential transformers are used on all medium and high voltages. The total power in the circuit is the sum of the readings on the three meters. Secondly, by means of a polyphase wattmeter composed of three single-phase elements, each element connected as in the former case. This type of meter has been practically abandoned in favor of the following type. Thirdly, by means of a polyphase meter composed of two elements, each comprising one potential and two current coils, as shown in Fig. 9. This instrument is a modification of the three-phase three-wire two-element wattmeter, to which has been added one current coil in each element. Another method giving approximately correct readings employs a regular two-element three-wire meter with three delta-connected current transformers, as shown in Fig. 10, with and without

potential transformers. It will be noticed that each current coil of the meter carries the resultant current of two transformers; therefore as a general rule the meter so connected must be of about 73 per cent larger current capacity than if it were to be used on a three-phase three-wire circuit for the same amount of power.

A particular case of loading occasionally met with is the combination of a three-phase three-wire load, such

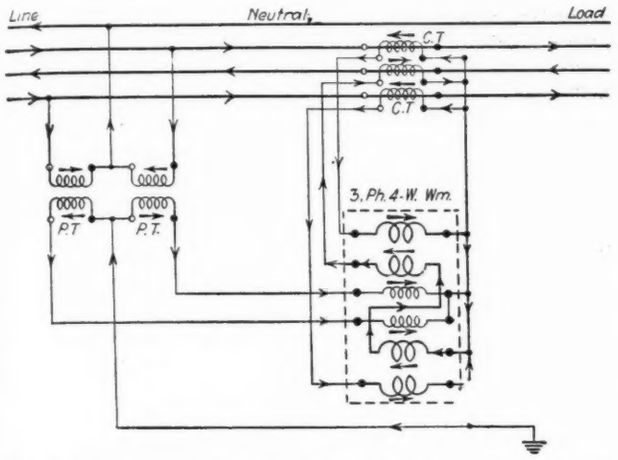


FIG. 9. MEASURING POWER IN A 3-PHASE 4-WIRE CIRCUIT WITH POLYPHASE WATTMETER AND CURRENT AND POTENTIAL TRANSFORMERS

as a motor load, and a single-phase load at half potential, such as a lighting load, between one wire and a fourth. This scheme requires two meters for correct measurement. A three-phase three-wire meter will measure the three-phase load correctly, while a single-phase meter must be used to meter the single-phase load.

In the foregoing examples it was assumed that only the instruments described were connected to the transformers; but in actual practice several instruments may be connected to one set of transformers, and must be so grouped and the transformers selected of sufficient capacity to give the correct ratio for that grouping. Two sets of transformers are sometimes used; one set supplies the accurate instruments whose indications represent commercial values, such as the watt and watt-hour meters, while another set supplies such apparatus as voltmeters, ammeters, power-factor and frequency meters, protective relays and synchroscopes. In deciding on the instrument connections, the inherent errors of an instrument transformer must be known. These errors are of two kinds—ratio errors, which affect all instruments connected to them and phase-displacement errors, which affect only such meters as watt and watt-hour meters, synchroscopes and power-factor meters. These errors in a well-designed transformer are always small; yet for extreme accuracy the transformer must be supplied with correction curves[2] or the transformers and instruments calibrated as a unit. The errors of transformers seldom change with age, and the effect of variations in wave form of ordinary frequency is so small that it is always negligible. Voltage transformers are usually chosen so that normal primary voltage produces 110 volts on the secondary. The primary voltage should not vary more than 10 per cent from the rated voltage. Current transformers should be chosen so that normal full load in the primary produces 5 amperes in the secondary. A 50 per cent overload, or 7.5 amperes in the secondary, should safely be carried by the transformer and all instruments. Transformers should always stand the ground test recommended by the A. I. E. E. This is twice normal operating voltage plus 1,000 volts and should be applied to both current and potential transformers for about one minute.

POWER CONSUMPTION OF POTENTIAL ELEMENTS OF VARIOUS ALTERNATING-CURRENT INSTRUMENTS

25 *Cycles*

Instrument	Volt. Amp.	Watts	React. Comp.	Power Factor
Voltmeter	10.9	9.7	5.0	89
Wattmeter	7.6	6.65	3.7	88
Power-factor meter	9.7	7.3	5.5	79
Frequency meter	24.0	18.0	16.0	75
Relay (induction)	12.5	2.5	12.2	20
Regulator	60.0	48.0	36.0	80

60 *Cycles*

Instrument	Volt. Amp.	Watts	React. Comp.	Power Factor
Voltmeter	10.9	9.7	5.0	89
Wattmeter	7.6	6.65	3.7	88
Power-factor meter	9.7	7.3	5.5	79
Frequency meter	24.0	18.0	16.0	75
Relay	22.2	3.3	22.0	15
Regulator	60.0	48.0	36.0	80

Owing to their internal losses transformers will vary slightly from the theoretical ratio, and this causes inaccuracy unless the transformer is compensated. In other words, the theoretical voltage ratio may be 2,200 to 110, but the actual ratio under load may be only 2,200 to 109. Therefore the transformer has more turns added to the secondary to compensate for the drop, so as to change the theoretical ratio, for example, to 2,200 to 111 and the actual ratio under load to 2,200 to 110.

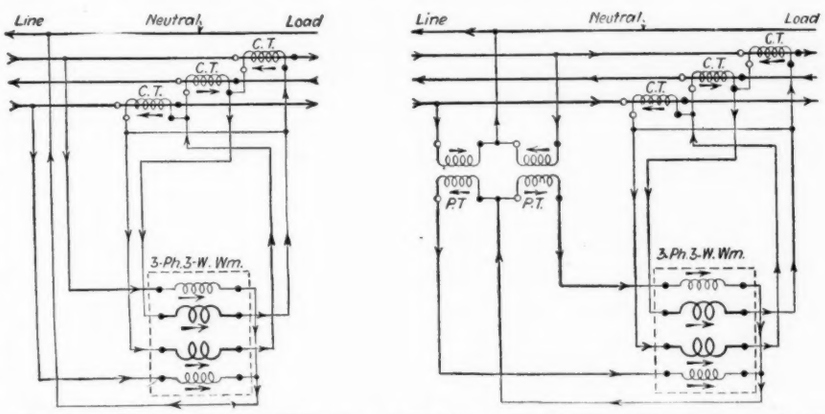


FIG. 10. MEASURING POWER IN A 3-PHASE 4-WIRE CIRCUIT WITH 3-PHASE 3-WIRE METER AND DELTA-CONNECTED CURRENT TRANSFORMERS, WITH AND WITHOUT POTENTIAL TRANSFORMERS

The voltage ratio is dependent, however, on the secondary load. This must be clearly distinguished from the load on the system, as the load referred to here is only the energy expended in supplying the instruments. When inductive-type instruments are used, the watts and reactive components of energy consumed by each instrument must be known. A typical list of watts and reactive components consumed by different instruments of one make is shown in the table, only the potential element being listed.

[2] See article on "Instrument Current Transformers," by J. B. Gibbs, in *Power*, Feb. 1, 1921, page 175.

To find the total volt-amperes that the transformer will have to supply, square the total watts and the total reactive components or magnetizing watts, add the squares and extract the square root from the sum. For instance, if it is desired to find the volt-amperes drawn by a voltmeter, a wattmeter and a frequency meter connected in parallel on the secondary of a potential transformer, the values taken from the table must be put in the following form:

Total volt-amperes

$$= \sqrt{(5.0 + 3.7 + 16.0)^2 + (9.7 + 6.65 + 18.0)^2}$$

$$= \sqrt{24.7^2 + 34.35^2}$$

= 43.47 volt-amperes

The power factor of the combination may be determined by dividing the total watts by the total volt-amperes. For instance in this case, 34.35 divided by 43.47 gives a power factor of 79 per cent. A transformer must next be selected which is compensated for this load; or if a standard transformer compensated for a certain load is used, the combination of instruments must be changed to approximate as nearly as possible the rated load of the transformer. Phase displacement cannot be compensated for in the transformer, but it is possible to obtain correct indications from the meter by calibrating both transformer and meter as a unit. As a general rule, when the power factor of the secondary load on a voltage transformer is high, the reversed secondary voltage lags with respect to the primary; in other words, the phase displacement of the transformer is lagging; and when the power factor of the load is low, the phase displacement is leading. The phase displacement of a current transformer is almost invariably leading.

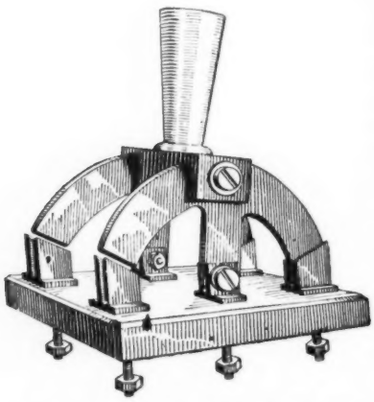


FIG. 8. D. T. SWITCH FOR CURRENT TRANSFORMERS

Entropy of Steam

BY M. J. EICHHORN

The formula given by Callendar for the entropy of dry steam is

$$N = 0.477 \log_e \theta - 0.1101 \log_e p - Zp - 0.217$$

in which $Zp = \frac{ncjp}{\theta}$, $n = \frac{10}{3}$, $j = \frac{1}{1400}$, $c = C_0\left(\frac{\Theta_0}{\theta}\right)^n$,

and $c = \frac{1.2014}{\left(\frac{T_1}{273} + 1\right)^{\frac{10}{3}}}$.

Putting p_1 = absolute pressure in pounds per square inch and substituting the constants, this reduces to

$$Zp = \frac{0.4199\ p_1}{\left(T_1 + 273\right)\left(\frac{T_1}{273} + 1\right)^{\frac{10}{3}}}$$

By a further substitution of the value of Zp in the equation for N, a single equation is obtained between the three variables: N = entropy of dry steam; T_1 = temperature of steam in degrees Centigrade; and p_1 = absolute pressure of steam in pounds per square inch. Consequently by observing that $p = 144 \times p_1$, $0.1101 \log_e p = 0.1101 \log_e p_1 + 0.1101 \times 4.969813 = 0.1101 \log_e p_1 + 0.54718$.

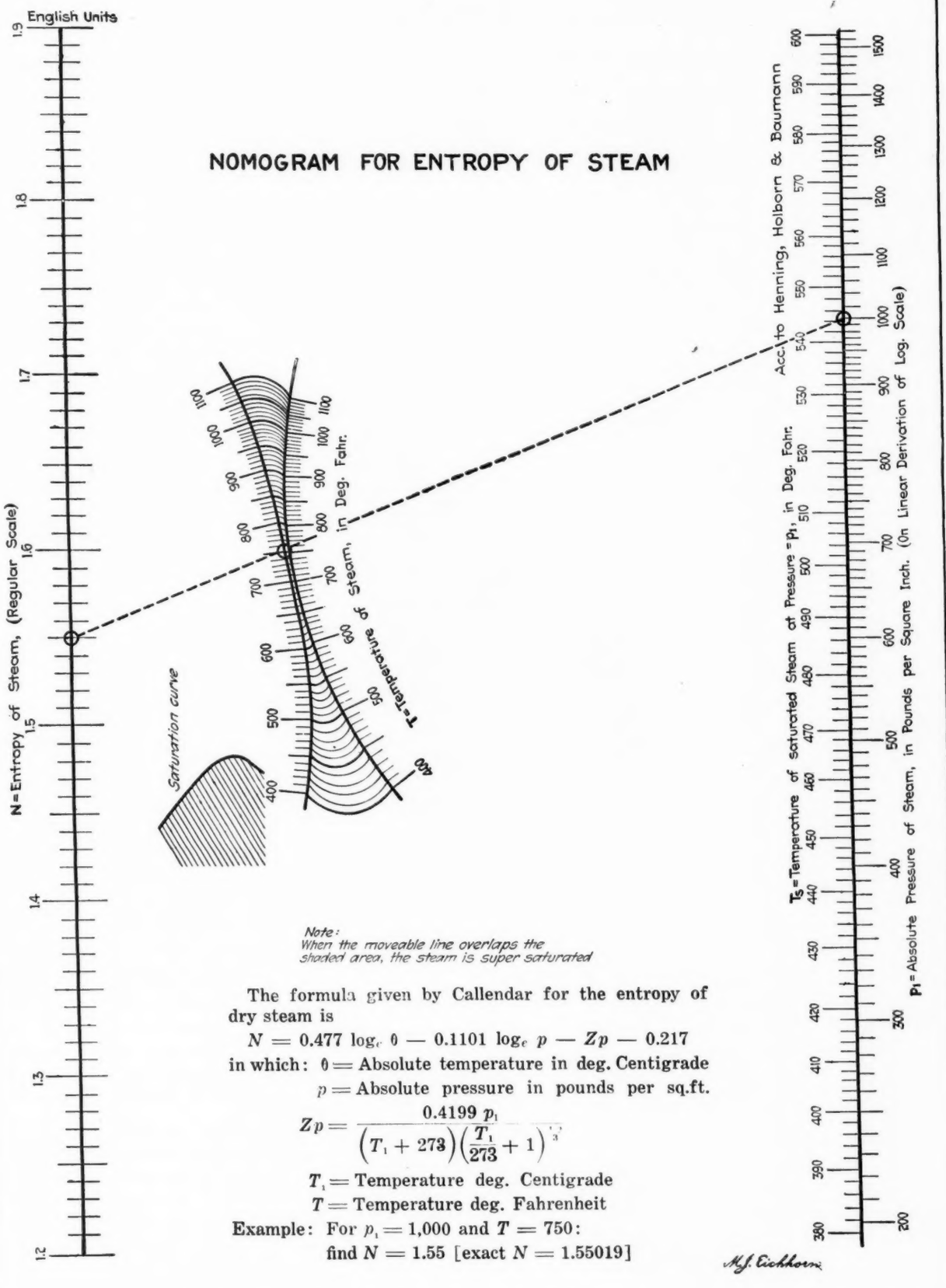
The complete formula so obtained is of such a form that it requires for exact representation by means of aligned points one straight and two curved scales, which naturally involves a very considerable amount of additional calculation. In this case the construction of a tangential nomogram offers a solution involving less numerical work. The finished nomogram is shown in the chart on the opposite page and is used by connecting the point representing the entropy with the one representing the absolute pressure and finding the curve to which this line is tangent and the number of which gives the temperature. The visual interpolation requires the finding of a curve intermediate between those drawn, and is comparatively easy, but not quite as direct as with the nomograms which appear in *Power* May 17 and May 31.

The top scale, used for the entropy, is a regular or uniform scale, and the bottom scale for the pressure is a linear derivation of a logarithmic scale, obtained after a few trials. The method adopted, which I have found useful in a number of cases, was to radiate lines from a point through the division marks of a suitable logarithmic scale, and graduating a new scale on a line placed at an angle with the first-mentioned scale. The approximate location of the main points in the desired scale is previously obtained in such a manner as to make the central part of the temperature range very nearly a point. After obtaining the base scale and adding the graduation representing the temperature of saturated steam, the next step is to solve the original equation for the entropy, so as to obtain, for each value of the temperature, at least three pairs of values of N and p_1. Considering the three lines thus located, as tangents to a short curve, it is then easily possible to determine the same with a fair degree of approximation.

Professor Callendar has in his tables introduced to concept of "supersaturated steam," under which he comprehends the unstable states of the vapor when the temperature is suddenly lowered below that of saturation.

I have drawn the saturation curve and shown a shaded area to its left; thus, when the movable line is tangent to the saturation curve, then the steam is in the saturated state, and when the movable line overlaps the shaded area, then the steam is supersaturated and in an unstable condition, which may be compared with the well-known phenomena of a supersaturation solution of salt in water.

Consideration will be given in the designs for the proposed power plant at Morwell, near Melbourne, Australia, to recovering the byproducts from the fuel that would be required for raising steam. In that case the boilers would have gas fires. If it is considered preferable to burn raw coal, an experiment will be made of feeding it in the pulverized form to the furnaces. Another experiment will be made with feeding small coal and dust to a forced-draft traveling-grate stoker. The commissioners have made arrangements for putting down an experimental briquetting plant, at a cost of about £30,000, which will briquet 70 tons a day. The ultimate capacity of the power station, it is proposed will be 100,000 kilowatts.—*The Engineer.*


English Units
NOMOGRAM FOR ENTROPY OF STEAM
N = Entropy of Steam, (Regular Scale)
T = Temperature of Steam, in Deg. Fahr.
Saturation curve
Acc. to Henning, Holborn & Baumann
Ts = Temperature of saturated Steam at Pressure = P1, in Deg. Fahr.
P1 = Absolute Pressure of Steam, in Pounds per Square Inch. (On Linear Derivation of Log. Scale)
M.J. Eichhorn

Note:
When the moveable line overlaps the shaded area, the steam is super saturated

The formula given by Callendar for the entropy of dry steam is

$$N = 0.477 \log_e \theta - 0.1101 \log_e p - Zp - 0.217$$

in which: θ = Absolute temperature in deg. Centigrade

p = Absolute pressure in pounds per sq.ft.

$$Zp = \frac{0.4199\, p_1}{\left(T_1 + 273\right)\left(\frac{T_1}{273} + 1\right)^{3.3}}$$

T_1 = Temperature deg. Centigrade

T = Temperature deg. Fahrenheit

Example: For $p_1 = 1{,}000$ and $T = 750$:

find $N = 1.55$ [exact $N = 1.55019$]

Brake Adjustments on Gearless-Type High-Speed Traction Elevators

Action of Elevator During the Stopping Period—Effects of Counterweighting—The Stopping of a High-Speed Traction Elevator—Controller and Brake Adjustments Explained in Detail

By W. ZEPERNICK

CONDITIONS under which an elevator must be stopped are many, ranging between the extremes of full load in up motion and full load going down. In this article attention is given to an Otis high-speed direct-traction machine of the type shown in Fig. 1. In order to give a clear conception of the load in either case, it will be assumed that the elevator is counterweighted for 40 per cent of its capacity load; this is the usual amount of counterweighting, but subject to 5 or 6 per cent variation, depending on the service to which the elevator is applied. Counterweighting for 40 per cent of capacity load indicates that the counterweight will weigh as much as the elevator car plus 40 per cent of capacity load. Assume the case where the following weights are involved: Elevator car, 3,000 lb.; capacity load, 2,500 lb.; counterweight, 3,000 + 40 per cent of 2,500 = 4,000 lb.

With full load in the car going up, the motor must lift an unbalanced load of (3,000 + 2,500) — 4,000 = 1,500 lb. In stopping, gravity assists by virtue of the unbalanced load of 1,500 lb. With full load in the car going down, the unbalanced load manifests itself by driving the motor as a generator, and in stopping, gravity opposes the braking action with a pull on the hoisting ropes equivalent to the unbalanced load of 1,500 pounds.

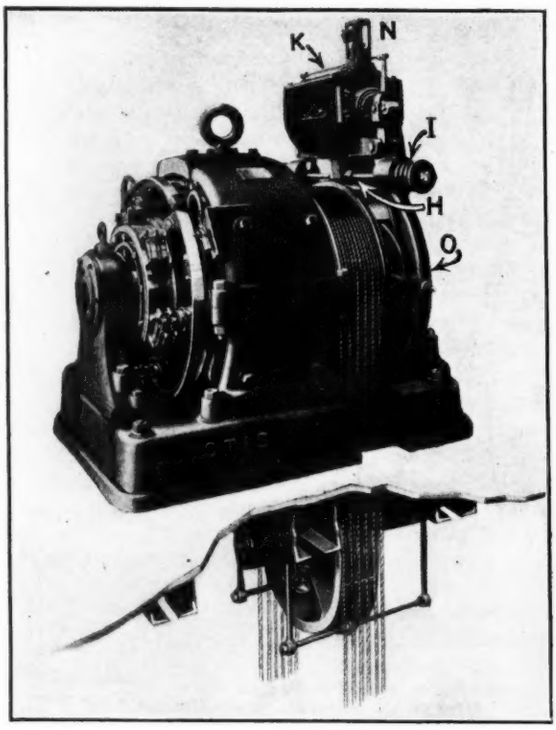


FIG. 1. DIRECT-TRACTION ELEVATOR MACHINE

The difference between the two extreme conditions in stopping is a positive action of 1,500 lb. in the first case and a negative action of 1,500 lb. in the second case. This is equivalent to a difference of 3,000 lb. pull on the hoisting ropes between stopping on the up and stopping on the down direction with full load.

From the foregoing it must not be understood that the unbalanced load alone must be considered in the stopping, but every pound of the equipment in synchronous motion with the machine tends to keep the equipment in motion when the power is cut off. This energy, which is the energy that must be dissipated in stopping the elevator, is the energy required to start the equipment and build up or accelerate the elevator to full speed. The unbalanced load assists or opposes the stopping, depending on whether the motor is lifting or lowering the unbalanced load.

The energy of a moving mass is proportional to its weight times the square of its velocity, therefore the required braking action increases as the weight and the square of the speed. Twice the mass requires twice the braking action; double the speed requires four times the braking power. Neglecting friction of the moving parts, there are three distinct factors that determine the stopping of an elevator:

1. The force of gravity due to the unbalanced load which assists or opposes stopping, as described in the foregoing; in the case of a balanced load there is no action due to gravity.

2. The motor acting as a generator when power is cut off, the kinetic energy of the equipment serving as the driving power. Current is delivered to suitable resistance, called a bypass resistance, mounted on the controller where energy is dissipated as heat as follows: The shunt-field winding is connected across the line, thus providing for a field at all times. The armature is connected to a bypass resistance which is cut in and gradually short-circuited as the machine comes to rest (see Fig. 2). A voltage is induced in the armature conductors rotating in the field. This voltage causes a current to flow through the bypass resistance, where it is dissipated as heat. The energy thus dissipated is a measure of the average voltage, average current and time in which the elevator is stopped.

By short-circuiting the armature, a very abrupt and unpleasant stop may be obtained owing to the fact that the amount of current flowing through the armature circuit is determined by the low resistance of the armature conductors, brushes and leads only. This current will be extremely high, the average voltage remaining practically the same (decreasing from the same maximum to zero); the time of stopping must be less since the same energy is dissipated as in the previous case Generally speaking, the bypass resistance across the

armature must be of such value that most of the stopping is provided by the current in the armature circuit without obtaining an abrupt stop, the brake shoes serving as an auxiliary only. However, the brake shoes must provide sufficient holding power to hold the elevator at rest under all conditions of load.

Various loads change the condition under which the elevator must be stopped. This variable condition is taken care of automatically to a considerable extent by the motor. When the car switch is centered to bring the elevator to a stop, the voltage available in the armature winding immediately delivers current to the bypass resistance. The value of this current is determined by the induced voltage or counter-electromotive force of the armature winding and the resistance of the armature circuit.

Consider a negative load which is the case when lowering a load heavier than the counterweights. Under this condition the motor does not take current from the line, but in most cases delivers current back to the line, the amount of current depending on the amount of unbalanced load which is the driving power for the motor acting as a generator. When the unbalanced load is not sufficient to overcome the losses in the machine, the motor will draw current from the line. The induced voltage available in the armature in the former case will be equivalent to line voltage E plus the voltage drop IR in the armature winding and expressed in the form of an equation is, counter-electromotive force $= E + IR$. The available voltage when the motor is lifting an unbalanced load, armature drawing current

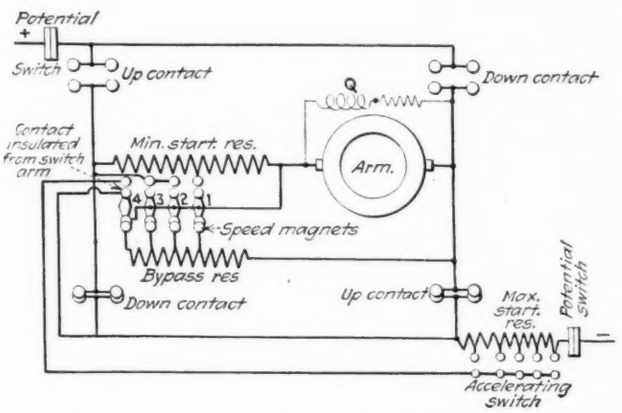


FIG. 2. DIAGRAM OF MOTOR CIRCUITS, FIG. 1

from the line, is equal to line voltage minus the IR drop in the armature, or counter-electromotive force $= E - IR$.

In the first case gravity tends to oppose stopping and in the second case assists stopping. When the car is on the down motion a greater stopping effect is obtained from the motor because of the greater counter-electromotive force available, while on the up motion a lesser counter-electromotive force is obtained, resulting in a reduced stopping effect of the motor. In this way the stopping effect of the motor automatically opposes the action of gravity.

3. The friction of the brake shoes upon the brake pulley is the third action that is utilized in the stopping of an elevator.

The counterweighting and value of the bypass resistance are fixed when an installation is completed, and for this reason the brake holds the greatest attention. In making repairs or relining brake shoes, the brake is dismantled, and upon completion of such repairs the brake must be readjusted. The principle upon which the brake derives its braking power will now be considered.

Braking power is obtained by reason of the friction of the brake linings upon the brake pulley and expressed in the form of an equation for a given speed, is,

Friction = pressure × coefficient of friction

where friction is expressed in pounds pull on the brake pulley, pressure is that due to the springs, and coefficient of friction is a constant determined by materials in contact, temperature and speed of brake pulley.

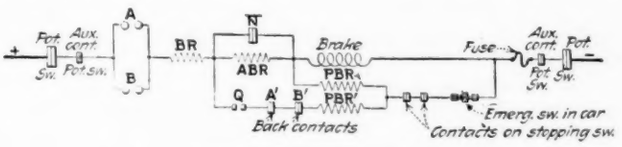


FIG. 3. DIAGRAM OF BRAKE CIRCUITS

The brake linings in most general use are leather or multibestos, the writer preferring the latter because of its more constant coefficient of friction obtainable with different conditions of temperature and speed. Another preference for the multibestos linings is in the case of the brake obtaining undue slide, squeaking or abrupt stopping caused by oil or gummy substance on the brake linings. With the multibestos linings it is a simple matter to saturate the linings with gasoline and burn them clean. With leather linings it is more difficult to clean without extreme care.

In order to have a good brake action the surface of the pulley and brake linings should be kept perfectly clean, as the introduction of any foreign substance will change the value of the friction, thereby either causing a quicker stop or increasing the distance the elevator slides.

The next point in good brake operation is to maintain the minimum clearance of the brake shoes from the pulley when the brake is lifted, and the spring tension on the brake shoes should be equalized, otherwise the brake shoe with the greater tension will press against that side of the brake with the greatest force, tending to spring the shaft on which the pulley is mounted. Failing to give due consideration to these two points in brake adjustment is the principal cause of most brake troubles.

Fig. 3 shows the electrical circuits involved with the brake winding. The resistances used are, *BR*, brake resistance; *ABR*, auxiliary brake resistance; *PBR*, parallel brake resistance; *PBR'*, auxiliary parallel brake resistance. The purpose of the *ABR* resistance is to reduce the current in the brake winding after it has lifted the brake shoes clear of the pulley. This reduces subsequent heating in the brake magnet, at the same time providing for quick release of the brake when starting. This resistance is used on brakes with single windings that are connected across the line when the elevator is started. With another type of brake a compound winding is used. A heavy or series winding is connected in series with the armature and short-circuited out after the brake has lifted, serving the same purpose as the *ABR* resistance. The *PBR* and *PBR'* resistances are for utilizing the energy stored up in the brake electromagnet to provide for a slow application of the brake shoes to the pulley.

A flywheel in motion tends to keep turning after the power is cut off; in the same manner an electromagnet tends to remain energized when the current is cut off, provided there is a circuit through which the current can flow when the line current is interrupted. The *PBR* and *PBR'* resistances provide this circuit. This current prevents the magnetic field from decreasing at a rapid rate, thus slowing up the application of the brake shoes. The electrical circuits of the brake are such as to provide three different applications of the brake. At the terminal landings it is desired to provide a more positive braking action than at the intermediate landings. The object of this would be to prevent excessive run-by, and second, because of the automatic slow down, the brake application may be harder at the terminal stops than at the intermediate landings. The application of the brake at the intermediate floors must be more gradual, for running at high speed, should the brake be applied immediately, upon stopping not only would there be an unpleasant and very abrupt stopping action, but the brake linings would have but a very short life due to excessive wear. The third application of the brake is in inching to floors where it is desired to level the elevator platform with the landing. In this case it is necessary to provide for a very quick action. In inching up to floors it requires very close adjustment of brake shoes to the pulley, for should the brake shoes lift too great a distance, the period of time required for the shoes to move through the clearance would permit the load to overhaul. By overhauling is meant the action of the unbalanced load moving the elevator between the time power is cut off the motor and the time the brake shoes are applied to the pulley. The adjustment of the brake to obtain the best operation will now be considered

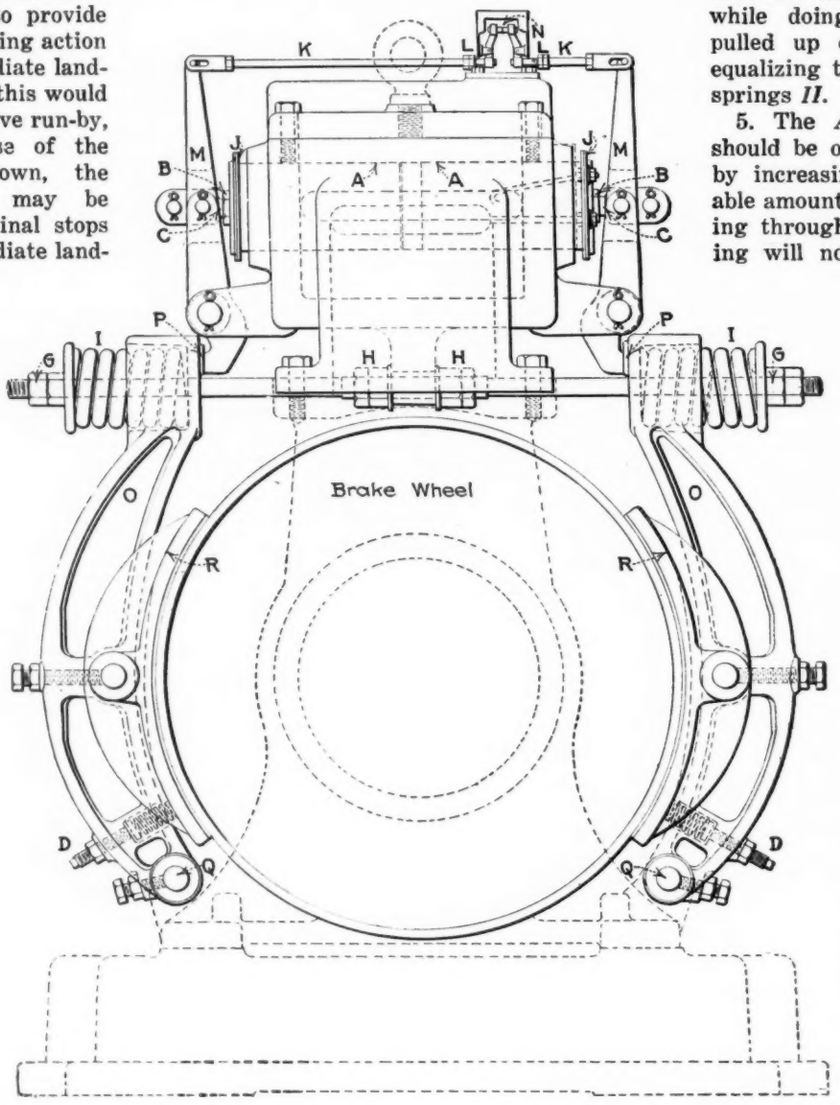


FIG. 4. DIAGRAM OF BRAKE EQUIPMENT

1. Brake shoes and pulley must be perfectly clean.

2. Adjust magnet cores *AA*, Fig. 4, to obtain the minimum lift by unlocking nuts *BB* and moving cores *AA* either in or out as desired. Magnet cores *AA* are drilled and tapped, and are moved in or out by turning the cores on the threaded studs *CC*. Equalize the lift at the top and bottom of each respective shoe by screwing in or out studs *DD* to obtain the required results.

3. Adjust nuts *LL* on the braking switch *N* so that when the brake magnet has pulled in, the contacts are opened the minimum distance required to break the arc.

4. Tighten up nuts *GG* to obtain the spring tension necessary to give the desired stop with full load. The nuts *HH* should be slacked off while doing this and then pulled up equally to insure equalizing the tension on the springs *II*.

5. The *ABR* resistance should be of such value that by increasing it an appreciable amount, the current flowing through the brake winding will not be sufficient to hold against the pressure of the springs. This value of *ABR* provides for the magnetic field set up by the current in the brake winding to be of sufficient value to hold against the springs with a small decrease in voltage.

6. Leather washers *JJ* keep the cores *AA* from butting and should be of sufficient thickness to provide a positive release of the cores when power is cutoff. The principle involved is the introduction of an air gap which will weaken the residual magnetism to such an extent that it will not prevent the magnet cores from releasing. At the same time these leather washers provide for a softer blow when the magnet cores pull in instead of striking metal to metal when operating.

Referring to Fig. 3, the manner in which the various circuits in connection with the brake operate will be considered. The *BR* resistance is permanently connected when used, for the purpose of reducing the current in the brake circuit to the smallest value necessary for the operation of the brake. The *ABR* resistance is short-circuited by a contact mounted on top of the brake-magnet frame and actuated by rods *KK*, Fig. 4.

adjustment being made by threaded nuts *LL*. When the brake magnet is energized, the magnet cores *AA*, attached to lever arms *MM*, pull in opening contact *N*, introducing resistance *ABR* into the brake circuit, thereby reducing the current, lever arms *MM* at the same time striking lever arms *OO* at the point *P* causes the latter to move about point *Q*. This motion of lever arms *OO* causes the brake shoes *RR* to clear the brake pulley. As mentioned before, the contact *N* should be so adjusted as to open the minimum distance required to break the arc.

Resistance *PBR* is of comparatively high value, while *PBR'* is of low value. *PBR* resistance is in series with

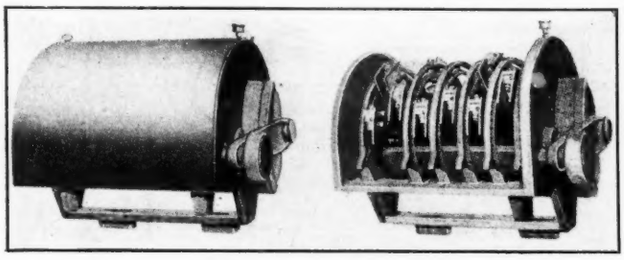


FIG. 5. AUTOMATIC STOPPING SWITCH, WHICH IS LOCATED ON TOP OF CAR

two contacts which are mounted on shaft limit switches in the case of earlier-type machines, while in the latter type these contacts are mounted in the stopping switch, Fig. 5, mounted on the crossbeam of the car sling. *PBR'* is in series with a back contact on each direction switch and also with a contact which is operated by a magnet *Q* (see Fig. 2) connected across the armature. This latter magnet operates only when the motor has come up to a definite speed or to that speed where voltage across the armature is of sufficient value to operate the magnet. *PBR'*, together with these contacts in series with it, parallel the *PBR* resistance.

The operation of the brake is as follows: When the car-switch control handle is moved for either direction of travel, the respective direction switch will operate. Auxiliary contacts mounted on the direction switches close the brake circuits. These contacts are indicated at *A* on up-direction and *B* on down-direction switch, Fig. 3. *A'* and *B'* are back contacts on the up and down direction switches respectively. These contacts are made when the direction switches are released, and *A'* opens when the up-direction switch closes, and *B'* opens when the down-direction switch pulls in; therefore, when either direction switch pulls in, the *PBR'* circuit is opened. At this time current flows through the brake magnet coil, and the *ABR* resistance is shorted out by contact *N* mounted on the brake. Resistance *PBR*, paralleling the brake, takes a very small amount of current from the line, but serves no purpose at this time.

When the brake magnet lifts, contact *N* is opened, which cuts in the *ABR* resistance, reducing the current in the brake winding and thereby decreasing the heat losses in the brake circuit

After the motor builds up to about 50 per cent of normal speed, magnet coil *Q*, Fig. 2, pulls in, which opens contact *Q*, Fig. 3. When stopping, magnet *Q* will not release until the motor has come down to a very slow speed, therefore when the direction switch releases, the *PBR'* resistance is still open-circuited until low speed is obtained. Under this condition, at the first application of the brake at the intermediate landings its action is a trifle harsh for the reason that the *PBR'* circuit is opened; when the motor has slowed down to the point that magnet *Q* releases and closes its contact *Q*, because of the low resistance of the *PBR'* resistance, the brake application is softened for the slower speed. The brake application is first harsh and then eased off as the elevator comes to a stop. At the terminal landings, when the contacts mounted on the stopping or limit switches as the case may be, are opened, all parallel brake-resistance circuits are opened, preventing any circulation of current through the brake coil when the elevator is brought to a stop. This provides for a hard application of the brake shoes.

When inching to floors, the magnet *Q* will not open contact *Q* for the reason that the motor does not reach sufficient speed to operate this magnet, the voltage across the brushes not being sufficiently high. The method by which a quick application of brake is obtained is as follows: That period of time that is necessary for direction switches to release and close their back contacts *A'* and *B'* is sufficient time for the brake to apply and stop the elevator. The *PBR* resistance should be high enough to accomplish this.

A summation of the various resistances and their functions is given in the following: Increasing the resistances has the effect indicated and decreasing them gives the opposition condition.

BR—Increasing *BR* resistance decreases the total power consumption of the brake circuit.

ABR—Increasing provides less heating and quicker application of brake shoes and eases off the blow at limit of car travel.

PBR—Increasing provides harder application of brake at intermediate landings immediately upon centering car-switch control handle; also provides quicker application of brake when inching up or down to a landing.

PBR'—Increasing provides a harder application at intermediate floors when stopping from high speeds.

Rebuilding an Old Oil Engine into a Modern Type

BY EDGAR J. KATES

Fifteen years ago, when oil-engine design had not progressed to its present well-developed status, the Hornsby-Ackroyd engine, invented in England, had a wide vogue. Many of these engines were sold in the United States, being manufactured here under the name "De La Vergne Type HA." Fig. 1 illustrates the design of the single-cylinder engine. These engines were in their day considered the latest word in efficiency and serviceability, and hundreds were installed in all parts of the country.

The fuel consumption of the type "HA" engine, per brake-horsepower was 0.90 lb. at full load, 1 lb. at three-quarter load and 1.12 lb. at one-half load. The fuel was restricted to kerosene and fuel oils lighter than 24 deg. Bé. and also some of the lighter crude oils produced in the Eastern and Middle States.

In spite of the excessive fuel consumption and the necessity of using a high-grade oil, to say nothing of the disadvantage of having to heat the vaporizer with a torch before starting, it should be remembered that these engines were perfectly satisfactory in their day.

Of late years, however, oil-engine design has progressed at a rapid rate and present-day oil engines consume less than half as much fuel for the same power, start up immediately from a cold condition and will run on cheap and heavy grades of fuel which would quickly clog a type "HA" engine with carbon.

Modern engines use higher compression and have far better methods of atomizing the fuel and forming a combustible mixture. The higher compression is made possible by injecting the fuel at the end of the compression stroke, thus making pre-ignition impossible. The old type "HA" engines inject the fuel during the suction stroke, so that the vaporizer contains a combustible mixture during the latter part of the compression stroke and therefore the compression pressure must be kept quite low to prevent pre-ignition. Modern engines also have better-formed combustion chambers, which make it possible for all the fuel charge to meet all the air, thus forming a homogeneous mixture.

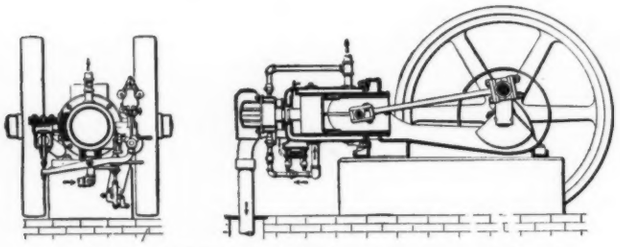


FIG. 1. ORIGINAL DESIGN OF "HA" ENGINE

One of the highly developed types of modern oil engines is the solid-injection engine. This is a single-acting four-stroke-cycle engine having a compression of approximately 330 lb. per sq.in. and a fuel consumption of only 0.41 lb. of oil per brake-horsepower-hour. It operates on any grade of crude or fuel oil commercially produced, irrespective of gravity and can be started up instantly from a cold condition without resorting to preheating or electric ignition. A detailed description of this engine appeared in *Power*, Dec. 28, 1919. Nearly all the old type "HA" engines installed ten to fifteen years ago are still running and are good for many years more of active service, but they are hopelessly inefficient when judged by modern standards. Obviously, it would be highly desirable if such engines could be rebuilt at moderate expense into a modern type. It is interesting to note that this development work has been undertaken. Fig. 1 shows a type "HA" engine as originally built, while Figs. 2 and 3 are views of the engine after being converted to the modern solid-injection type.

The change consisted in installing a new cylinder casing, cylinder liner, piston, cylinder head and valve gear, governor and fuel pump, or in other words renewing the combustion end of the engine. All the wearing parts were thus replaced with new ones with the exception of the crankshaft bearings and the half-speed gears. Inasmuch as the mean effective pressure of the solid-injection cycle is considerably greater than that of the type "HA," the new piston was made considerably smaller in diameter while maintaining the full original horsepower. This resulted in the further advantage that the total stresses in the engine frame, etc., were well within those permitted by the original design.

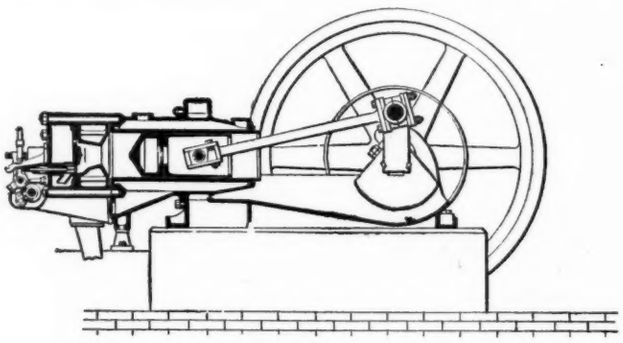


FIG. 2. "HA" ENGINE WITH NEW PARTS

The conversion was successful from the start, and a much poorer and cheaper grade of fuel was found to give perfectly satisfactory results. Fuel-consumption tests on the converted engine showed a fuel saving of 50 per cent in weight of fuel, which, on account of the cheaper fuel, means a still greater saving in money. The engine can now be started in less than a minute instead of requiring, as before, ten to fifteen minutes for preheating the vaporizer cap with a blast torch. The speed regulation, which is now controlled by a modern type governor, is much closer than before, and altogether most of the superiorities of the modern solid-injection oil engine have been most creditably incorporated into this very old design. Because of the better combustion the former necessity of cleaning the combustion chamber every week has been removed. In every way the change is a decided improvement.

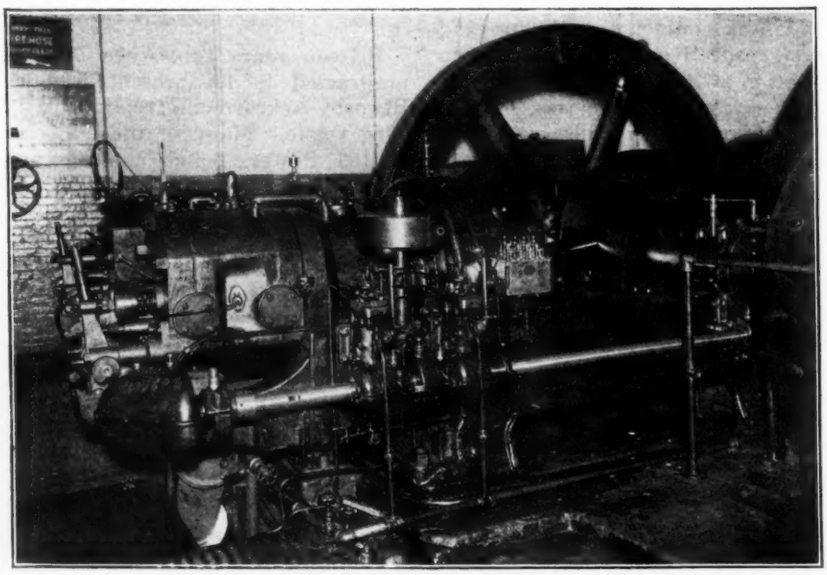


FIG. 3. "HA" ENGINE AFTER CONVERSION TO SOLID-INJECTION ENGINE

W-R, CO_2 Indicator

In the general run of power plants the CO_2 content of the furnace gases from any one of a number of boilers is either intermittently or continuously analyzed from but one boiler at a time by a single machine. A simple CO_2 indicator, Fig. 1, has recently been put on the market by the Yarnall-Waring Co., Philadelphia, Pa., and is designed for application one to a boiler. It requires no liquid reagent, is continuous, needs little attention, and the percentage of CO_2 is registered on a graduated scale continuously.

Referring to the diagrammatic view, Fig. 2, the flue gas is taken from the last pass of the boiler through a preliminary filter, not shown, and is drawn continuously through the indicator by the steam-jet aspirator *A*.

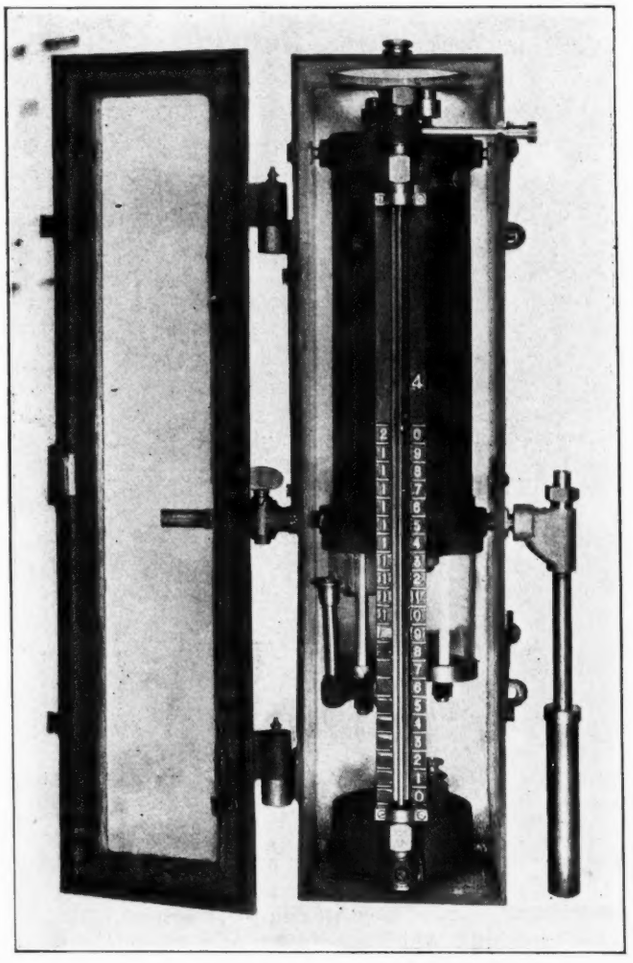


FIG. 1. SIMPLE DESIGN OF CO_2 INDICATOR

The gas enters the machine through the pipe *B* and passes through a secondary filter *C*. As the gas is discharged into the bottom of the filter, it must pass up through the filtering material, through the tube *D* into the chamber *E*, where a portion of it percolates through the porous pot *F*. This gas comes in contact with the dry reagent cartridge *G*, and all the CO_2 contained in the gas is absorbed by it. The gas sample that does not come in contact with the dry reagent cartridge passes down through the tube *H* into the glass flow indicator *I*, where it discharges below the water seal and, bubbling up through the water, is drawn out through the gas outlet *J* by the steam aspirator *A*.

The pressure inside the porous pot *F* is always less than that in the chamber *E*, because of the absorption of CO_2 by the dry reagent cartridge *G*, and this difference in pressure is a positive measure of the CO_2 content of the gas sample, which is continually indicated on the scale *K*, the tube of which is connected near the top to the porous pot, the lower pressure being at the bottom to the reservoir *L*, which contains colored water. As the pressure in the reservoir *L* is the same as that in the chamber *E* and greater than the pressure in the porous pot, the colored water is forced up in the glass indicating tube *K*.

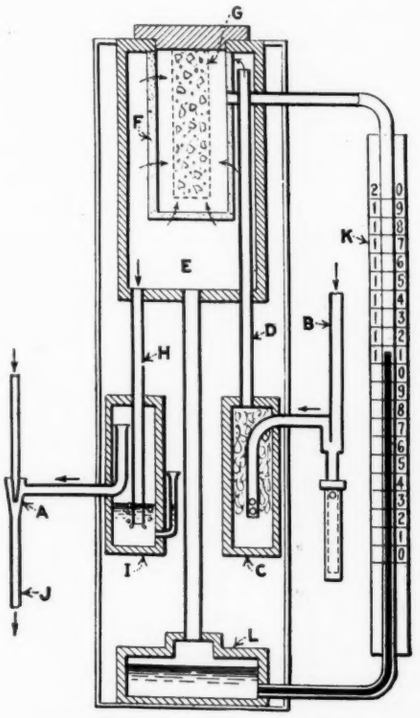


FIG. 2. DIAGRAMMATIC VIEW OF CO_2 INDICATOR

The more CO_2 present in the gas the greater vacuum there will be in the porous pot *F* and, therefore, the greater rise of water in the indicator column. With a decrease of CO_2, the vacuum will be less and the water column in the glass gage will fall. The scale is graduated to indicate the percentage of CO_2, at which level the colored column of water indicates.

With an instrument connected to each boiler and placed where the fireman can readily watch the gage indication, it is possible to regulate the furnace fire so as to obtain the best possible combustion of the fuel. In order to have a record of each furnace performance, a recording vacuum gage may be attached to the indicator at any desired point, the inches of vacuum recorded showing the percentage of CO_2 indicated by the indicator gage.

Large holes can be rapidly made in glass with a piece of copper tube having a serrated edge fitted with crystals of carborundum. It is not the hardness of the glass which causes the trouble, but the heat created by the friction of the drill. It will be found preferable to leave the glass in cold water while drilling it.

Underground Steam Lines in Dayton

More Than Two-Thirds of a Mile of 10,- 12- and 14-inch Pipe Without a Screwed or Flanged Joint

TO ENABLE the Dayton Power & Light Co., of Dayton, Ohio, to carry out its contract with General Motors Corporation to supply steam to its subsidiaries, the Delco Light Co. and Dayton Engineering Laboratories, an interesting installation was recently completed by the American District Steam Co. as engineering contractor.

The pressures maintained at the plants referred to are 125 and 75 lb. respectively, steam being used in both for heating and process purposes as well as for the operation of pumps, fans and auxiliary apparatus in general.

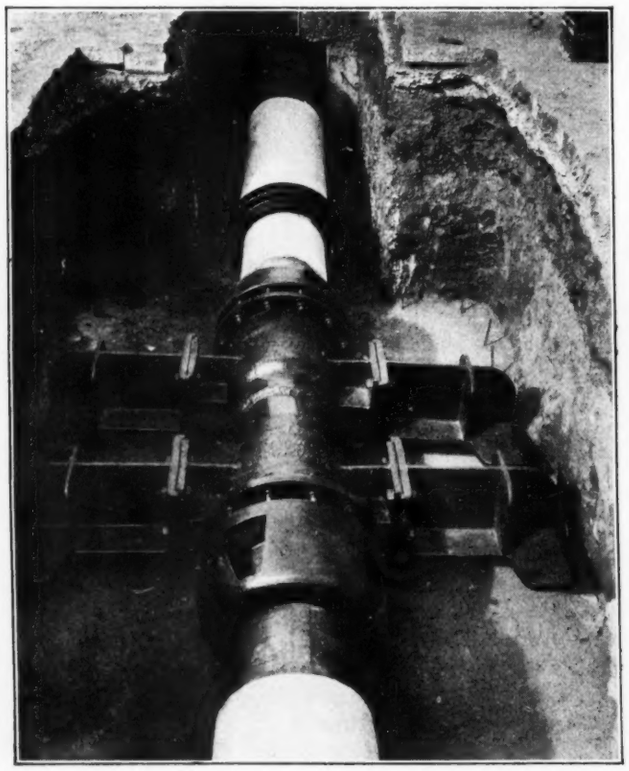


FIG. 1. PAIR OF EXPANSION JOINTS COMPLETE, READY FOR POURING SIDES OF MANHOLE

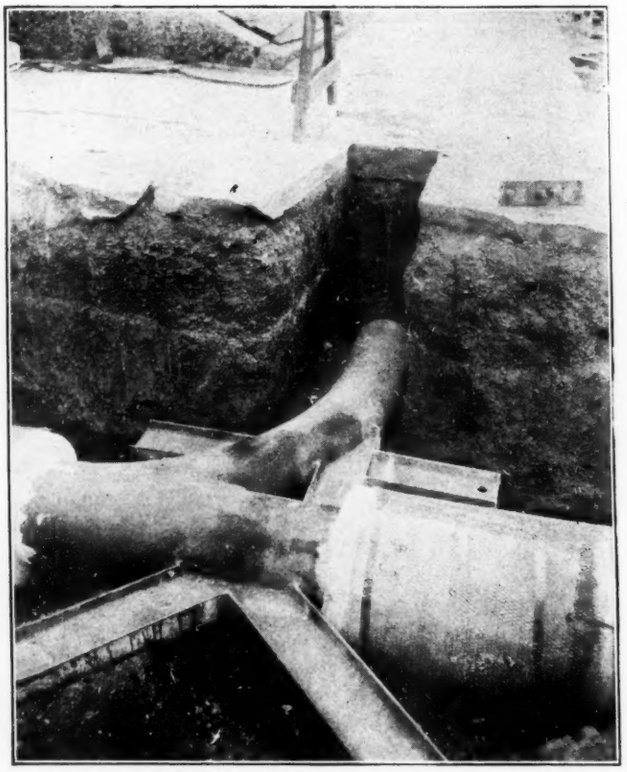


FIG. 2. TEN-INCH PIPE BEND WELDED INTO FOURTEEN-INCH LINE AND ANCHORAGE

In the underground system itself, not including piping and equipment in the power house and plants served, the distances for the several sizes of pipe are as follows: 14-in., 1,145 ft.; 12-in., 1,321 ft.; 10-in., 1,109 ft.; total, 3,575 ft. In this entire distance there is not a screwed or flanged joint, all pipe and fittings being welded together by the electric-arc process. The total number of welds is 274, equivalent to a running length of welded joint of 895 feet.

The expansion joints are extra-heavy, cast-steel, duplex-sleeve, side-anchorage, guided type, with ends machined for welding direct to pipe line. While each unit is complete, they are placed in pairs, back to back, with a short nipple welded between and a single manhole inclosing both joints, each of which has sufficient traverse of slip to accommodate at least seven inches of expansion in the pipe. Fig. 1 shows such a pair installed ready for pouring the manhole sides.

There are four right-angle bends in the system, all of which are anchored by welding I-beams, suitably cut, to the pipe and embedded in reinforced-concrete piers. In one case such a bend in a 10-in. pipe is welded into the 14-in. main line, as shown in Fig. 2. At one point a reverse bend was necessary in the 12-in. line to enable it to pass under two sewers and over a water main, with a rise of 2½ ft. in 10 ft. of length. This was made of seven short pieces of pipe welded together.

The trenching, which was in soil of a gravelly nature, was in general about 4½ ft. deep, although in a few places it was necessary to excavate to 8 or 9 ft. in order to avoid obstacles such as water mains, sewers, electric conduits, etc. The conduit through which the steam line is laid is of concrete, with a bottom 6 in. thick, carefully graded to conform to the pipe line and reinforced by iron bars spaced 18 in. apart and bent to extend up about 8 in. into the side walls, which are also 6 in. thick.

All pipe was covered with asbesto-cell sectional sponge felt covering 3 in. thick, securely banded in place. The joints of the two layers were staggered both longitudinally and transversely. The covering was then wrapped with expanded metal lath laced together to

conform with the circumference of the covering, and over this was applied a hard finish of a mixture of one-third portland cement, one-third plasterer's sand and one-third nonpareil insulating material. This thickness averaged from ¼ to ½ in. The surface was troweled to a smooth finish, precautions being taken to prevent cracking as the mixture dried. The fittings were covered with asbesto sponge felted block covering in sections and securely wired in place. The metal lath was then cut to fit and laced around the covering, and the hard finish applied as on the pipe. Fig. 3 shows clearly details of the covering.

For the purpose of insuring perfect alignment of the pipe with reference to expansion joints during movements of expansion and contraction, and to provide substantial supports, special alignment guides were installed at approximate intervals of 30 ft. These guides consist of a fixed element anchored by bolts to the concrete foundation, and a movable element clamped to the pipe. The guides are placed on exact center line

FIG. 3. WELDED JOINT, BASE OF ALIGNMENT GUIDE, AND DETAILS OF PIPE COVERING

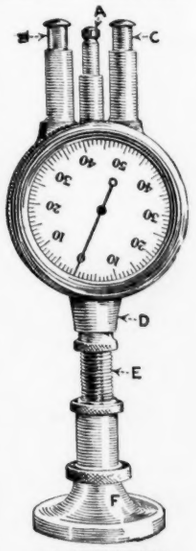
both in elevation and direction. Openings are provided in the casting of the case to allow free drainage in the conduit through the guides. Fig. 3 shows an alignment guide base set in place and the lower half of clamp with pipe line lying in it. It is apparent in this picture that the covering on the pipe is free to move within the outer shell of guide, when expansion takes place.

After the line was in place and the covering applied, saddle plates with rollers and supports were placed underneath the covering. The saddle was pressed up tightly against the covering, and the roller, in its support, was shimmed up from the concrete base to hold the saddle firmly in place. These were installed to prevent any danger of sagging of the covering between alignment guides.

In spite of the fact that there were various unexpected and unavoidable delays it was found possible to complete the entire installation within five months from the time the work was started.

Crankshaft Alignment Indicator

An alignment indicator used in the alignment of crankshafts of new engines and for checking the alignment of crankshafts of engines in service, is being put out by Ruscon & Hornsby, Ltd., of Lincoln, Grantham and Stockport. According to the *Engineer*, of London, it is comprised of a dial that is provided with a scale graduated in thousandths of an inch, and a pointer that is actuated by a spring plunger *A*. Two additional spring plungers, *B* and *C*, are arranged on either side of the plunger *A*, and normally project farther away from the center of the dial than does the plunger *A*. Diametrically opposite to the plunger *A* is a lug *D*, which is threaded to receive a screwed rod *E*, to the other end of which is attached a circular base *F*.

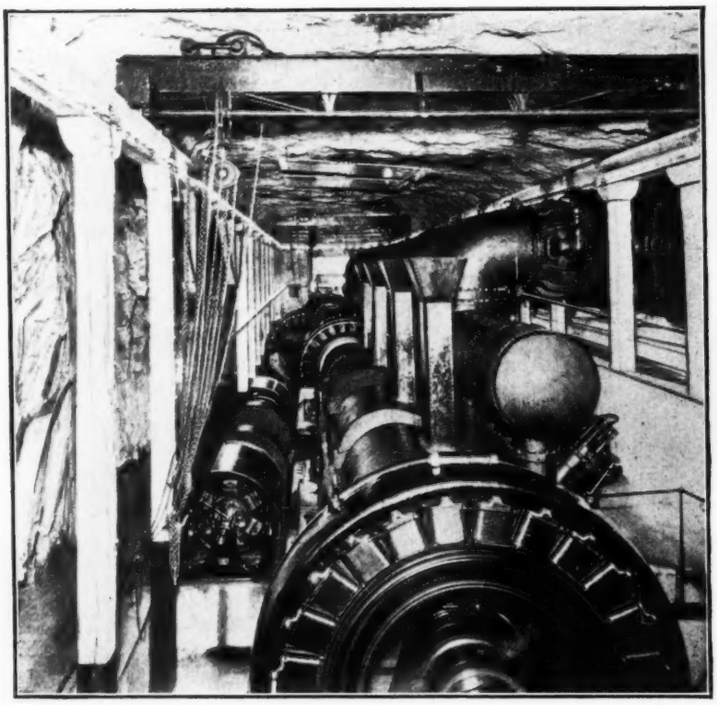


ALIGNMENT INDICATOR

The apparatus is employed to measure the distance between the inner faces of the crank balance weights or of the outer ends of the crankwebs, first when the shaft is in one position and then when it has been moved one-half revolution. In setting instruments it is only necessary to place the base *F* bedded against the inner base of one of the crankwebs, and then revolve one of the knurled nuts so that the length of the threaded rod is so adjusted that the two spring plungers *B* and *C* impinge upon the corresponding face of the other crankweb, and are sufficiently compressed, not only for the plunger *A* also to impinge on the crankweb, but for the pointer to be revolved through, say, half a turn. The dial can be revolved by hand, independently of the pointer, until the pointer is opposite the zero mark. Next, the shaft is moved to 180 deg., and if the pointer still remains opposite the zero mark, it is known that the shaft is in alignment.

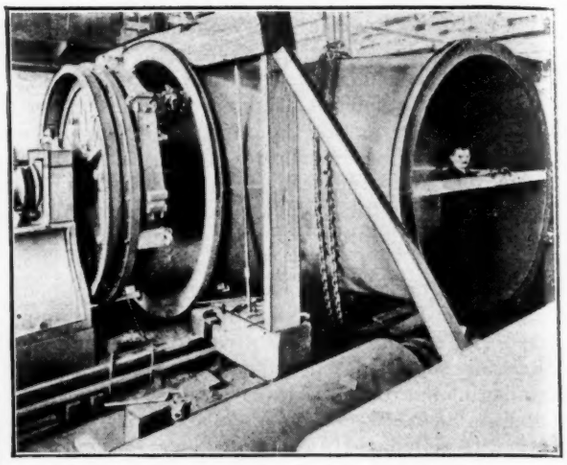
If, however, the pointer, instead of remaining at zero, shows a movement either to one side or the other, then the revolving of the shaft has either brought the bases of the crankweb nearer together or has forced them farther apart. A movement in either direction shows that the alignment is out. If the shaft is out of alignment, adjustments are made until the deflection of the pointer from the zero mark is brought down to one-half of what it originally was. The dial is then revolved until the pointer is again at zero, and the shaft is again revolved to 180 deg. If the adjustment has been properly made, the pointer will have remained opposite zero. If it has not, it is necessary to make further adjustment following the same procedure as before.

Ordinarily, the instrument is adjustable for use in any size of crankshaft in which the distance between the webs is not less than 4½ in. or greater than 9½ in.



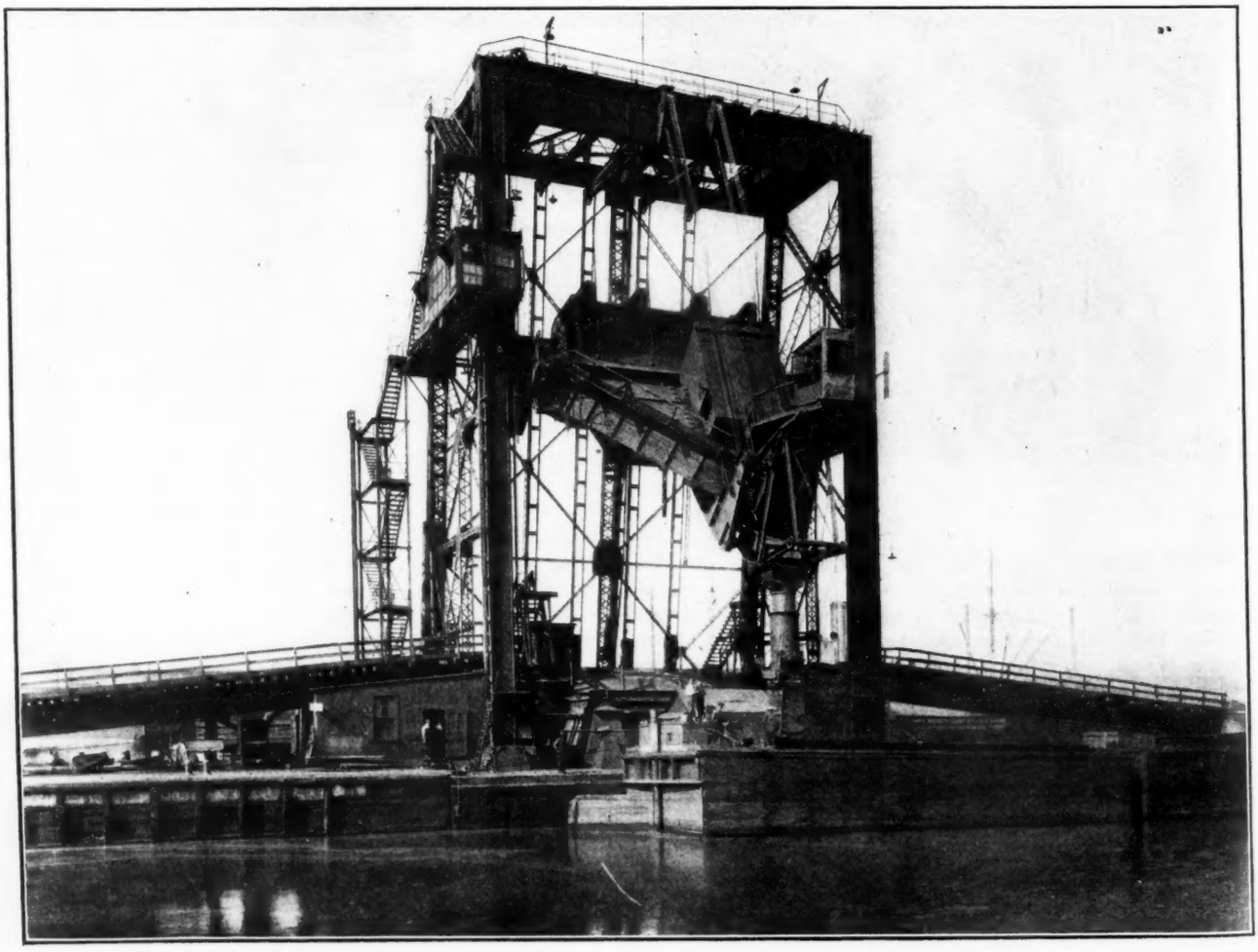
A subterranean power plant—the Snoqualmie Falls hydro-electric generating station, located in a large cavity cut into the solid basalt 268 ft. below the surface of the river.

Courtesy of the National Electric Light Association.



A 96-in. cast-iron elbow for a 10,000-kw. turbo-generating unit being machined. The total weight of the casting is 25,600 lb.

Power-plant executives with coal-handling problems of their own to meet will be interested in the steam elevator shown below, which picks up a freight car and dumps its load of coal through a chute into a barge. It is in operation at the terminal freight yards on the Delaware River at Philadelphia. The loaded freight car is hauled up the inclined tracks on one side and, after being dumped, is started down the other side and shunted onto sidings.



EDITORIALS

Scope of Fact-Finding

A CONFERENCE held on June seventh was proposed in order to determine somewhat further the proper scope for fact-finding investigations of the Government with respect to coal. Bituminous-mine operators, anthracite operators, wholesalers, retailers and an assortment of officials interested in one phase and another of the subject were asked to participate. By some this conference appears merely a perfunctory affair, since it is charged that "the program seems cut and dried" in advance of the meeting. On the other hand, some real results of value were anticipated by those sponsoring the occasion.

It would seem almost a waste of time to try to confer on whether we need some facts about the coal business. The experiences of 1920 would appear to any impartial observer as more than a justification for additional collection of facts by the Government. Yet certain interests, notably the wholesalers, oppose any such effort. How long they can hold out against the inevitable remains to be seen, but right-minded people certainly will hope that they cannot long continue to stem the tide of demand for all essential facts regarding production, stocks and distribution of so essential a commodity as coal. Less than this is wholly inadequate, and for the Government to provide less will be a neglect of one of its fundamental duties to the American people.

Those who are backing the effort to have the importance of coal recognized and to have ample information gathered currently regarding it, deserve the most cordial commendation and vigorous support. The impartial observer as well as the interested coal user will wish them well in their effort.

Permits for Government as Well as for Industry

FEDERAL investigations of power developments in their various phases do not always run the smoothest, most direct course to their destination. Frequently, the competition between departments or actual conflict of interest of the several Federal agencies is most regrettable; and under the present system of management of these affairs, it is practically impossible to avoid this friction and duplication of effort. It seems, however, that a very simple remedy for the situation is right at hand.

It is now required that any private enterprise that desires to make development of power projects on the public lands in the national forests or on navigable streams affecting interstate commerce, must secure appropriate permit and approval from the Federal Power Commission. At the same time several Federal agencies are going forward with various investigations affecting these industrial developments quite without regard to each other in some cases. For example, in Alaska one of the Governmental departments is making certain power studies for the Federal Power Commission, but declines to handle its work in co-operation with one of the other branches of the Government, also active there, even to the extent of permitting direct co-operation of the field agents. This situation continues despite the fact that this co-operation in the two parts of the work has been requested by the Federal Power Commission. The result is that every action taken by the one agency must come to its Washington headquarters, be referred through official channels to the headquarters of the Power Commission, be referred to the Washington headquarters of the other department affected and sent by it to its field agent in Alaska. One can well imagine that the interval between the dispatch from Alaska and return to the field representative of the second department there will be weeks or even months. This may make a difference of a whole season in the prosecution of certain studies, for the season at best is short in that climate. In another case two separate agencies are working on the same river, one studying features of navigation, the other stream-gaging measurements, each quite without regard to the other's results, so far as the outsider can discover.

If all these activities could be co-ordinated through one Government office, no one need lose any of that "official dignity" which is so precious to some Federal administrators, and yet a real increase in efficiency would doubtless be quick to follow. It would seem that this co-ordination might easily be accomplished if it were simply required that all Government power studies, whether done by the Geological Survey, the Forest Service, the Army Engineers, or any other branch of the Government, should be passed upon by the Power Commission. This would not result in subordinating one bureau to another department than its own, for the Power Commission is made up of the secretaries of those three departments that have activities in the fields of power or power development. Any projects proposed by any one of the three might, for courtesy's sake at least, be submitted to the other departments for consideration and comment. Even this, however, would not seem to be quite enough, and it does not appear at all unreasonable to expect that the actual approval of the Power Commission be asked for the several classes of work that are planned. This could easily be done in any appropriation bill affecting these departments if Congress would say that "hereafter no money appropriated in this or other legislation shall be used for investigation of power resources or power developments without first having the approval of the project by the Federal Power Commission."

The Power Commission certainly would be broad enough not to attempt any dictation to the several departments responsible. The commission now works with a staff provided by these several departments and probably will continue to do so for some time to come. Its only desire will be, therefore, to co-ordinate the related parts of the work and to eliminate anything that might seem to be duplication. It is likely that the duplication of work, except perhaps in the statistical field, where a serious conflict is now charged, is quite

small. But there are undoubtedly many opportunities for closer co-ordination, such as that cited for the Alaska situation, which should receive attention.

It is not necessary to wait for legislation to gain this co-operation; voluntary means are already at hand. The three department secretaries who form the commission might well agree, as they have the power to do, that they will not undertake within their several departments any efforts that have not passed the scrutiny or had the informal approval of the Power Commission itself. Such a gentlemen's agreement would accomplish much, perhaps even more than legislation to this end. If the power interests of the country want this action in the interest of efficient, prompt attention to their needs, they may perhaps accelerate such move by making their wishes known to the several departments with which they deal.

Don't Forget the Invisible Losses

IN THESE days, when almost everybody is discussing with such care, and rightly so, all possible refinements of design and operation, it is well never to lose sight of savings that can be easily made. Glaring examples of failure to do this can be found in the power-plant field. For instance, it cannot be denied that in many boiler rooms steam-heated surfaces are left uncovered for months or even years.

A visible loss, such as the escape of steam past a leaky stuffing box or gasket, insistently attracts the attention and more frequently secures prompt action. The bare tops of boiler drums, on the other hand, or a few feet of bare steam piping here and there may be more serious causes of waste. Yet these invisible losses remain practically unnoticed because they do their bad work so quietly.

There is much discussion regarding the relative merits of various heat-insulating materials. Opinions also differ as to the proper thickness. Both of these questions are of real importance, but care should be taken not to delay the actual work for several months by long meditation or discussion on the matter. The most important thing is to get the surfaces insulated somehow without delay. It should not be assumed from this that it is not of real importance to use the most suitable heat-insulating material and the thickness that is commercially most economical. However, the difference between a scientifically chosen heat insulation and one picked at random is small compared with the loss from a bare surface. Data obtained from many sources show that the savings obtainable by heat insulation are, as a rule, very great in comparison with the investment.

In general the whole cost of both the material and labor to insulate in the most approved manner will be paid back in less than six months. Therefore, rather than spend six months or a year in deciding the matter, it would be better to make immediate application of that standard insulating material which seems most suitable even though at some later time it might prove advisable to replace it by a more scientifically selected and applied insulation. Of course, if the most suitable insulation can be applied in the first case without causing any delay, so much the better.

To take a homely illustration, one might very well appreciate the fact that some coats are better purchases than others. At the same time one would not go coatless through a cold winter because he could not decide which coat he ought to buy. Likewise every foot of bare steam piping or other steam-heated surface should be covered somehow without delay unless there is some special reason for not doing so. It is usually true that the small amount of capital that it is possible to invest in heat insulation pays over 200 per cent yearly interest. Common sense dictates that the investment be made at once.

What He Might Have Said

APPREHENSIVE that the Superpower project for the Boston-Washington zone might entail some form of governmental control, Samuel Insull, in addressing the N. E. L. A. convention, launched what appeared to many a veiled attack on the plan. It is inconceivable that he should not have been thoroughly conversant with the facts, but if he were not, Mr. Murray's straightforward come-back should have allayed all fears in Mr. Insull's mind. With characteristic frankness Mr. Murray explained that the Superpower investigation is first and last a utility matter, that the information is being collected through utility channels, that the results will be checked by utility engineers only and that Government backing has been sought only with the idea of giving weight to the findings in the eyes of the public.

But Mr. Insull went a step farther; with due respect to the standing of Superpower Survey's chairman, he questioned the wisdom of placing the direction of such an investigation in the hands of a railway man. This remark Mr. Murray chose to overlook. He might have reminded the speaker, however, that although an early advocate of electric railways producing their own power, he later became convinced that it was better for them to stick to purely railway matters and leave the power problems to the utility. Moreover, he was broad enough to acknowledge this change in viewpoint by later signing a contract between the New York, New Haven & Hartford Railroad and the United Electric Light and Power Company, instead of adding to the railroad's generating plant. Although concerned for some years with railway electrification, Mr. Murray's training and experience has been primarily and broadly that of an electrical engineer, and as such his qualifications for the Superpower investigation are obvious.

The American Association of Engineers is carrying on an extensive experiment in putting into effect a somewhat radical policy of decentralization. The association's recent action in approving the allocation of sixty per cent of all initiation fees and dues to the local chapters is in sharp contrast to the policy of the older engineering societies. In the American Society of Mechanical Engineers, for instance, the local sections receive twenty per cent of the initiation fees and only about 8½ per cent of the membership fees; in this society a special effort has been made to strengthen the local sections, but, obviously, the effort has not been carried to such an extreme as is being done now by the American Association of Engineers. It is probable that the success of the latter society's plan will be determined largely by the manner in which the local chapters carry it into effect. If it proves successful, it may have an important effect upon the policy of other engineering organizations.

CORRESPONDENCE

Some Old-Time Engineering

In 1886 I was appointed chief engineer of a bank and office building in New York City while the building was in the process of construction. The heating was indirect and there were 36 tons of radiators placed on I-beams in a plenum chamber and four large fans driven by shafting and a horizontal engine, to force air through the radiators and to the ducts leading to the various offices. The building was erected on a 10 per cent basis, and the 36 tons of radiators were cast wrong and had to be returned and new ones made at the owner's expense. The ducts were not protected by any non-conducting covering; they were simply lined with sheet iron, and as the building was eight stories high, the air was cold before it got to the upper floors. The architect put open fireplaces in each office, and the smoke was led up to a hollow ceiling on the roof and was drawn out by four large fans to the atmosphere. On a Sunday or on a holiday, if the engines were not running, the fireplaces could not be used.

There were two hydraulic elevators in the building, and the pistons had to be packed from the top, as the bottom lengths of the cylinders were down under four feet of concrete. The architect compelled the elevator builders to reduce the width of the traveling sheaves, and as a consequence, the friction was too great per square inch on the bushings of the sheaves and no lubrication would prevent them from grinding away. The sheaves were renewed with wider and larger diameter bushings, and that trouble was rectified.

One of the cars had a bad pound or thud that made the passengers afraid to ride in it. The builder put grease and plumbago on the ropes and that stopped the trouble for awhile. I took the job in hand and chalked across the ropes and the head sheaves while the car was running slowly. Upon examining the chalk marks in the ways, when the car was at rest on the first floor, I found that the marks did not come in line. I then hoisted the traveling sheaves and the car with chain blocks until I got the cables off the overhead sheaves. Upon calipering the grooves, I found that there was $\frac{1}{8}$ in. difference in their diameters. Consequently, the cables running on the smaller diameter had to slide to catch up with the cables on the larger diameter, and that caused the pound. I had the head sheave replaced with a new one and had no further trouble.

The basement was so crowded with the flue from the boilers that ran on the floor from the front of the building to the rear, and with the fan-engine blowers and the 36 tons of radiators, that there was no room for an electric-light plant, as engines were at that time belted to high-speed dynamos. The slowest-speed dynamo the manufacturer would or could give me was designed to run at 300 r.p.m., and I had to send to England for a Brotherhood engine to drive it. I think Alfred Brotherhood, who was with the Manning, Maxwell & Moore Co. at that time, is still living, and if so, he can testify that this was the first direct-connected plant in New York City that was used to light its own building. At that time all the Edison Co. had was a small store in Pearl Street near Fulton St. Then they got a basement near Broadway on Cedar Street with straight-line and Armington-Sims engines. They built the dynamos in Goerick St. on the East Side. We had wooden cutouts and lamp sockets, and all wires were in plain wood molding. There were no knife switches—just brass plugs pushed in between two contacts to make the connection. The men on watch had a pocketful of plugs, one man pulling out plugs while the other put them in when changing connections.

New York City. JOHN REDMOND.

Locating an Air-Cylinder Knock

Three years ago I was a machinist in a steam plant in Arizona. We had several cross-compound blowing engines of 5,000 cu.ft. per min. capacity, running at 60 r.p.m. and pumping against 14 lb. line pressure. One of the cylinders developed a knock that gave us a lot of trouble to locate. As it sounded like a loose piston, we opened up the cylinder and tried the rod nut. We also opened up the steam cylinder on the other side of the engine and tried the rod nut, but found them both tight; the locknuts on the crosshead were also found tight. We next removed the follower of the piston in the air cylinder and removed the bull ring to examine the packing ring, but as it looked to be in good shape, the bull ring was replaced and the cylinder closed up. After keying up on all the bearings, the machine was started, but the knock was still there.

Next, we tried changing the lap on the outlet valves, they being of the Corliss type, and also put more tension on the springs of the bypass valves with the idea that this would surely remedy the trouble, but when the engine was started the knock was as bad as ever. I then came to the conclusion that it must be the ring, as we had tried everything else that might cause a knock. The follower and bull ring were removed, and this time it was found that the packing ring sagged from the top of the cylinder very slightly, owing to weak springs. After putting in a new set of springs,

the machine was started, and this time there was no knock.

As the ring sagged slightly and fitted in the groove between the bull rings, it would stay in that position until the pressure on the outside of the ring was greater than the pressure in the groove under the ring; then the ring would be forced to the bottom of the groove, producing a knock. Then the air pressure in the groove would build up, and when the pressure in the cylinder was released, it would force the ring out, causing it to knock again.

It may seem unreasonable to some to think that this could happen, as it would appear that if the air did force the ring up and down, it would have a cushioning effect and that the ring would not move with enough force to knock. But as the piston, in pulling the ring along the cylinder walls, brings the ring quite tight to one side of the groove, it is evident that there is considerable friction to overcome before the ring is forced down, but after the pressure has increased sufficiently to overcome this friction, there is several pounds difference, and the fact that it is harder to start a body than to keep it moving after it is started would tend to prove that it will have force enough to cause the ring to produce a knock. L. W. KELLY.

Antigo, Wis.

Double-Seated Bypass Valve

A double-seated, two-way bypass valve that I have designed is shown in Fig. 1. It is used in such cases as that shown by Fig. 2, which is a common connection for a steam-trap bypass. Fig. 3 shows the application

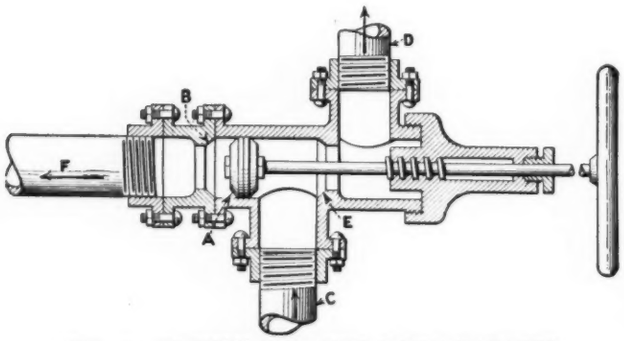


FIG. 1. SECTION THROUGH DOUBLE-SEATED BYPASS VALVE

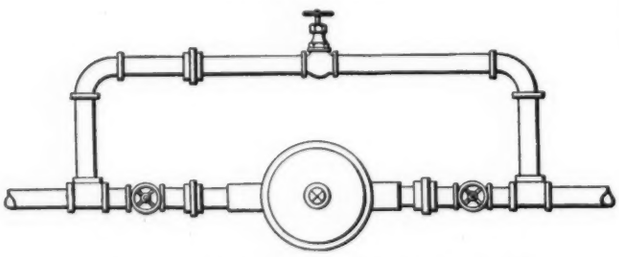


FIG. 2. A COMMON BYPASS CONNECTION

of the bypass valve (Fig. 1), which eliminates one valve used in the piping shown in Fig. 2, as but two valves are necessary for the same installation.

The valve can be used in any position. It is a two-way discharge valve with a double seat and a single disc and can be used on any part of the power-plant equipment that requires a full-open bypass. As shown, when the disc *A* is on the seat *B*, the flow is through the inlet pipe *C* and passes through the valve to the outlet and to the trap through the pipe *D*. When the disc is against the seat *E*, the flow is from the pipe *C*

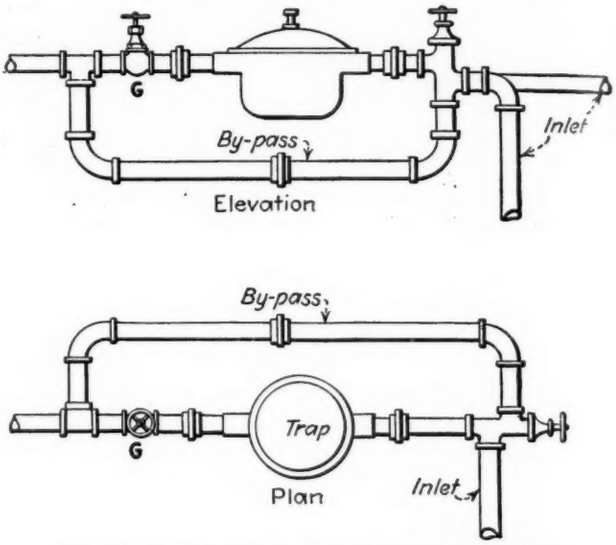


FIG. 3. APPLICATION OF THE BYPASS VALVE

through the valve to the bypass outlet *F*. With the valve *G*, Fig. 3, closed, the trap or meter may be removed for repair, renewal or for any purpose without interrupting the flow of liquid. W. L. TICER.

Washington, D. C.

Questionable Arrangement of Feed Pipe

In looking over the May 24 issue of *Power*, page 862, I read Mr. Green's description of a slotted internal feed pipe for discharging water in a thin film. On page 83 of the A. S. M. E. Boiler Code, par. 314, may be found the following: "The feed pipe of a boiler shall have an open end or ends inside of the boiler."

If I remember correctly, an interpretation of this paragraph, handed down by the committee not very long ago in a case where it was desired to provide the feed tube with a number of perforations, gave as the opinion of the committee that the perforations were all right provided the end of the pipe was left open. Apparently, Mr. Green's arrangement is contrary to the provisions of the Boiler Code. J. Y. SMITH.

New York City.

[Mr. Smith is correct in his interpretation of the A. S. M. E. Boiler Code.—Editor.]

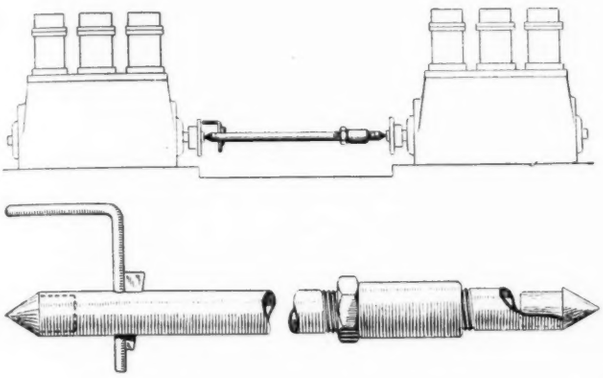
Aligning Engine Shafts

A method for aligning a double engine generator unit was asked by L. Harvey in *Power*, May 3. Judging from the layout, it calls for a precision job. The way to proceed is as follows:

Both engines should be set approximately in correct position on their respective foundations on suitable three-point-bearing leveling wedges or their equivalent. One engine should be leveled and bolted down to its foundation; then the second engine should be aligned with reference to it. First, a suitable gage whose length corresponds to the generator shaft should be

made and the second engine moved to correspond to this distance, care being taken that the lateral clearances of both crankshafts are evenly divided. A tram, which is shown in the illustration, is then carefully adjusted so that it has no lost motion when located in the centers of each crankshaft.

The pointer is adjusted until it touches the face of the flange about $\frac{1}{16}$ in. from the outer side, the wedge tightened and the tram rotated. Any error will show



METHOD OF ALIGNING ENGINE

at once and the second engine should be adjusted until the pointer touches evenly around the face of the flange, care being taken to keep correct distance and not disturb the lateral clearance of the crankshafts. When the engine is aligned, it is bolted down to its foundation. The generator shaft can now be coupled up and the air gap equalized around the rotor by adjustment of the stator.

G. STROM.

Erie, Pa.

Making Steam with Fuel Oil

An article, "Making Steam with Fuel Oil," in the March 29 issue, page 520, asks for records of users of fuel oil. I have always been of the opinion that published statistics of power-plant operation should be an incentive to operators to do better. By this I mean that a thoroughly intelligent study of oil burning makes possible higher efficiencies than can be obtained in burning coal.

There are a few fundamental principles to be observed for successful burning of fuel oil such as the following: Clean burners; cut the excess air for combustion to a minimum; cut the draft to a minimum consistent with a condition just free of sulphur dioxide; see that the air flow to the flame is so arranged that it does not excessively impinge the flame upon the tubes; use a minimum amount of steam or air for atomization; heat the oil consistently to a temperature just short of its flash point; keep the pressure of the oil uniform and keep the CO_2 between 14 and 15 per cent.

The tendency in burning oil is to run the boilers at a rating sometimes in excess of 100 per cent. It stands to reason that boiler settings will suffer in direct proportion to the boiler overload, and a very high grade of firebrick is necessary under such conditions. I have found that up to 75 per cent overload, no undue repairs are necessary to boilers or settings.

Blistering of tubes is usually caused by the cleaning not being thorough enough, and small patches of scale remaining on the tube encourage this action. The explanation given of corrosion in boilers by Sir John

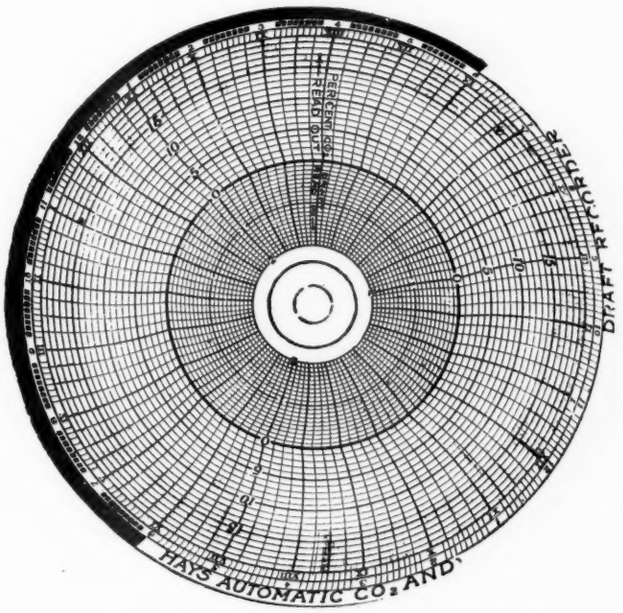


CHART SHOWING AVERAGE CO_2 OBTAINED

Dewrance before the A. S. M. E. has a direct bearing upon this matter. Necessarily, the faster the evaporation the more noticeable is the corroding and blistering action.

The accompanying test results are not from any dress-parade tests but are taken from actual, every-day test sheets for 24-hours run. This record has been kept now for a year, and with constant care and attention, the efficiency was raised about 8 per cent to its present average. The illustration shows an average CO_2 chart. These daily operation results are from 2,500 sq.ft. water-tube boilers. A back-shot burner is successfully used with heavy Mexican fuel oil.

GEORGE H. HUMM.

New Haven, Conn.

RESULT OF BOILER TESTS WITH FUEL OIL

Date—March	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Length of test, hours	24	24	24	24	24	24	24	24	24	24	24	24	24	24
Draft (outside and last pass), in.	0.07	0.04	0.07	0.07	0.09	0.07	0.06	0.07	0.07	0.07	0.08	0.06	0.07	0.07
Temp. of flue gases	420	425	430	400	390	335	285	380	315	380	345	320	315	285
Steam press., abs.	156.4	157.9	155.9	154.5	154.7	150.3	150.3	156.4	154.9	155.6	153.5	153.5	155.7	155.7
Superheat	90.4	99.4	92.4	90.4	90.4	95.5	91.5	90.4	91.5	90.4	89.5	87.5	84.4	84.4
Total water evap. (V-notch meter)	441,660	432,185	411,408	408,738	467,320	314,243	256,493	378,658	421,243	426,824	367,328	282,909	240,828	265,328
Heat value of oil as fired per lb., B.t.u.	18,450	18,450	18,450	18,450	18,450	18,450	18,450	18,450	18,450	18,450	18,450	18,450	18,450	18,450
Temp. of oil	132	138	142	146	144	162	144	148	142	144	142	148	152	148
Oil per hr. fired 60 deg.) (cor. for moisture), lb.	1,373	1,302	1,241	1,291	1,457	966	775	1,182	1,240	1,278	1,062	790	710	812
Sp. gra. of oil (60 deg. F.), Bé.	15.8	15.8	15.8	15.8	15.8	15.8	15.8	15.8	15.8	15.8	15.8	15.8	15.8	15.8
Steam used by burners	17,664	17,284	16,456	16,348	18,692	12,568	10,256	15,144	16,848	17,072	14,692	11,316	9,632	10,612
Water evap. per lb. of oil	12.92	13.26	13.24	13.2	12.83	13.00	13.25	12.82	13.58	13.37	13.8	14.3	13.56	13.1
Equiv. evap. from and at 212 deg. F.	13.58	13.92	13.9	13.87	13.5	13.65	13.92	13.47	14.27	14.04	14.5	15	14.23	13.76
Heat usefully emp., per lb. of oil	14,177	14,326	14,260	14,202	[13,813	14,020	14,262	13,782	14,611	14,380	14,828	15,335	14,543	14,038
Eff. of boilers and furnace	77	77.8	77.4	77.2	75	76.1	77.3	74.7	79.3	78	80.5	83.2	78.8	76.2

The Gas Producer

A letter from Dr. J. M. W. Kitchen published in the March 22 issue of *Power* sets forth his views in detail as to why producer gas power is not more commonly used in this country. The reasons assigned are numerous and varied.

One consideration to which great importance is attached is the claim of excessive capital investment in gas engines and producers as compared to the equipment necessary for a steam plant. The initial investment in gas power machinery for a plant of 1,200 hp. capacity is slightly greater than for a high-grade steam plant, but this difference is insignificant in comparison with the vastly better fuel economy of a well-designed gas power plant.

The wisdom of using producer gas for prime movers as against steam depends upon the relative cost of fuel available for gas making as against steam coal, and to some extent upon the character of the load. The writer's experience in connection with producer gas covers a period of nine years in the operation of three central station light and power plants located in the Middle West.

The combined capacity in producers installed in these three plants aggregates 2,500 hp. with an equivalent horsepower installation in gas engines. One of these plants has been in operation since 1912 at Flandreau, South Dakota. Anthracite buckwheat fuel is used exclusively. The equipment consists of suction producers built by the Smith Gas Engineering Co., Dayton, Ohio, and Rathbun-Jones 4-cycle gas engines. The results obtained in these plants refute most of the statements made by Dr. Kitchen.

The degree of intelligence and technical training required for the successful operation of these producer gas plants is, in the writer's judgment, no higher than would be required for successfully operating any other type of prime mover of equal capacity. The employees having the responsibility for plant operation acquired all of their knowledge and experience as gas engine and producer operators in the actual running of these plants.

The continuous and reliable service supplied to twenty-seven cities and villages furnished by these three generating stations is, in the writer's judgment, a conclusive answer to the questions raised as to the reliability of producer gas for power and the assumption that highly trained and expensive technical experts are necessary for results. The salaries paid in these three plants to the operating force are substantially in accordance with the prevailing scale of wages in steam plants of like capacity.

The so-called complexity in the process of gas making is, we find, more imaginary than real. Intelligent and careful operators are admittedly required in any well managed power plant. A knowledge of a few of the simple fundamentals of gas making is easily acquired by a man of average intelligence. A few months' training and the application of these principles results in the production of a uniform quality of gas. In the case of one plant now in the writer's charge the load conditions are exceptionally severe, the fluctuations in load being violent and sudden. This load will vary from 100 to 250 kw. rapidly, and is carried by a 400-hp. gas engine with an automatic voltage regulator on the switchboard with voltage and frequency fluctuations well within the recognized limits of good service.

The outstanding feature of producer gas is the great economy in fuel which is possible with intelligent handling. The results which actually have been obtained over a period of years show that with widely varying load and load factor, conditions not conducive to economy, the average results show a coal consumption varying from 2 to 2.3 pounds per kilowatt-hour delivered at the switchboard including all station auxiliaries.

Dr. Kitchen's conclusions that the successful operation of a producer gas power plant is "a fine art and can be exercised only by trained human brains expertly manipulating a poke rod manually" appears to the writer to be very wide of the mark.

Dr. Kitchen further states that "the simplified suction producer in which the prime mover incites the induced draft through the producer is a great cause of unsatisfactory results." The nine producers now in continuous daily service in the three plants referred to are of the suction type, and the foregoing summary of the results which have been consistently obtained day in and day out through a period of years is a flat contradiction of this last statement. The service equals that secured in a high-grade steam plant.

Under existing conditions with the price of fuel of all kinds at excessive figures the saving in the cost of operation by producer gas is noteworthy. Where the price of anthracite coal is prohibitive and lignite or other grades of fuel are available at a low price there are a number of very successful power plants in service operated by lignite burning producers.

ARTHUR H. SAVAGE, Treasurer,
Dakota Light & Power Company.

St. Paul, Minn.

Believes in Wrought-Iron Pipe

I have read the editorial on page 791 of the May 17 issue of *Power*, and I have also read several communications that have been printed in regard to the different kinds of pipe used on water lines. All these articles seem to carry the inference that wrought steel and cast iron or brass are the only materials to use.

Why use steel at all? Why not, in place of steel, use wrought iron? It will last from four to six times as long and costs but little more. I could never understand why steel pipe was so readily accepted and adopted by so many, especially after it had a few years' tryout. The only reason I can conceive would be that it is cheap, but does the cheapest always result in the best economy?

A wrought-iron water line conducting water fit for boiler use should last twenty years. I have known it to last that long and to be in good condition at the end of that period. I know of wrought-iron oil lines that have been laid for over forty years and are today working under pressure. In places these lines are exposed to water containing refuse and acids from chemical works.

I have wondered why, in all of the articles that I have noticed on this subject, there was no mention made of wrought iron. I am not a chemist and cannot explain the difference in the make-up of iron and steel, but steel pipe will pit with small holes in a short time, whereas iron pipe, when it does come in contact with anything that will cause erosion, scales off in a practically uniform manner, leaving the pipe thinner but without holes.

F. E. MYERS.

Charleston, W. Va.

INQUIRIES OF GENERAL INTEREST

Leaky Ammonia-Compressor Valve—How is it possible to detect leaky ammonia-compressor valves without taking indicator diagrams? P. G.

If the suction valve leaks, the frost will begin to disappear from the suction elbow, the suction pressure will show slight increase and the discharge pressure will decrease. If a discharge valve leaks, the compressor capacity will drop and the head pressure will drop, since a smaller volume of gas is being delivered by the compressor.

Importance of Viscosity of Fuel Oil—Why is the viscosity of oils used for boiler fuel considered as of leading importance, and how are relative viscosities designated? S. R.

The higher the viscosity of the oil the higher the temperature to which it must be heated for obtaining sufficient fluidity for pumping and handling, and in burning the oil the viscosity is the principal consideration because success of a burner mainly depends on its ability to atomize the fuel sufficiently for complete combustion. A common method of designating viscosity is in degrees on the Saybolt scale, which means the ratio of time for a given quantity of oil to flow through a standard orifice as compared with the time required for the same volume of water.

Adjustment of Damper Connections to Regulator—How should the amount of movement of a damper by a damper regulator be adjusted to the regulator? D. T.

For prompt control of the draft, the range of movement of the damper between the limits of no draft and maximum should be adapted to the operating range of action of the regulator rather than tax the regulator with damper movement beyond the limits of usefulness. The required range of damper movement can be determined by connecting a differential draft gage around the damper. With the damper first placed in the closed position, open it gradually and mark the position of the damper arm when the draft gage is first affected and then open the damper wider until the draft gage registers no drop and mark the position of the arm. The connection then may be adapted to obtain operation of the damper between those positions through the full range of action of the regulator.

Testing Alignment of Engine Crankshaft—How can it be determined whether the shaft of a side crank engine is in line without removing the piston and piston rod? F. M.

Remove the cylinder head, wedge a straight piece of wood across the counterbore flush with the end of the cylinder and on it locate the center of the counterbore. Place the crank on the center farther away from the cylinder and, from a wall or other stationary object behind the end of the cylinder, extend a fine line or wire tightly stretched alongside of the cylinder with the other end of the line made fast to a stationary object beyond the crank of the engine. Adjust the ends of the line so it will be level with and the same distance from the center of the cylinder and the center of the crosshead end of the piston rod at points in the line nearest those points of the engine. Then cut a light rod of wood or iron with rounded points at each end and overall length equal to the distance from the faced end of the crank pin to the line, and find whether the faced end of the crank pin is the same distance from the line when the crank is turned over to the opposite center. If the second distance is greater than the first, the outboard end of the engine shaft should be shifted toward the cylinder to make it square with the cylinder center line, and if less, the outboard end should be moved away from the cylinder.

Recovery of Condensate from Slasher Systems—What is the best method of returning the condensation of a heating and a slasher system to the boilers in case there is plenty of fall for delivery of the return water? J. E. W.

The heating surfaces of slasher systems are usually held responsible for the highest possible efficiency and often under conditions where, on account of the cramped arrangement of steam pipes, good air venting and satisfactory circulation of steam cannot be maintained without frequently blowing out the system direct to the atmosphere. Best results are therefore obtained with intermittent discharge traps delivering to a receiver that is vented to the atmosphere and where the condensate is returned from the receiver, by pump or trap, to the boiler. By keeping the trap valve in good condition, there will be more sudden relief of pressure and better sweeping out of air and water from the slasher coils when the trap blows; besides, the waste of steam will be reduced to a minimum. Direct return of the condensate to the boiler cannot be depended upon unless the slasher coils and connections have been so installed that satisfactory service can be obtained with the return line kept sealed against discharge of steam.

Operation of Induction Motor at Half-Voltage—A 50-hp. 440-volt 3-phase 60-cycle motor has a rated full-load speed of 1,140 r.p.m. What would be its speed and power output at the pulley if operated from a 220-volt supply, when drawing the same current as at full voltage and full load? J. P. J.

To keep the primary current the same as at full voltage and full load, the secondary current must remain practically the same. But the flux at half voltage will be half that at full voltage. Therefore the rotor bars must cut this flux twice as fast to generate the same current, that is, the slip must be double that at full voltage.

The motor in question is evidently a 6-pole machine, the synchronous speed of which is 1,200 r.p.m. Therefore its slip is 1,200 − 1,140 = 60 r.p.m. The slip at half-voltage therefore will be 120 r.p.m., and its speed will be 1,200 − 120 = 1,080 r.p.m.

The torque at half-voltage and rated full-load current will be one-half that at full-voltage. The speed is $\frac{1,080}{1,140}$ times full-voltage speed. Therefore the power output will be

$\frac{1}{2} \times \frac{1,080}{1,140}$ times full-voltage output, or

$\frac{1}{2} + \frac{1,080}{1,140} \times 50 \text{ hp.} = 23.68 \text{ hp.}$

Loss of Load Causes Racing of Engine—We have a shaft-governor engine working condensing which drives an electric generator and when the circuit breaker opens the engine races badly. How can the trouble be remedied? W. J. V.

The racing is due to the impulse imparted by steam in the cylinder after the load goes off and before the supply comes under complete control of the governor. The trouble may be aggravated by unequal cutting off in opposite ends of the cylinder, leakage of steam valves and sticking or worn governor connections. Have the valves made tight and put the governor in good working order by a thorough cleaning and replacement of the pins or other worn parts.

Speeding up Engine May Reduce Steam Economy—Why cannot greater economy be obtained by speeding up an engine to permit of shortening the cutoff from ¼ to ⅛ stroke for the same load? C. S.

With earlier cutoff and higher rate of expansion there is an increase of cylinder condensation, due to greater changes of temperature. For that reason simple engines are limited to four or five expansions as an economical maximum. For cutoffs between one-fifth and one-third stroke, the economy is about the same, but if made less than one-fifth, the increased loss from condensation may be greater than the gain from increased expansion and in addition the higher speed required for the same load would result in a higher percentage of power lost from engine friction.

Providing for Expansion of Steam Line—Should not a 6 in. steam line 120 ft. long that carries steam at 110 lb. pressure be provided with one or more expansion joints? J. S.

The greatest amount of total expansion of length between the limits of freezing temperature of the weather when the line is not in use and the highest temperature of the steam when in use would be about 3 in. Generally it is advisable to provide suitable anchorages to prevent longitudinal movement of a line near the point where it is supplied, and if the supply is at one end, there should be at least one expansion joint near the supply end of the line and an anchorage at about the middle of its length. If the supply and longitudinal anchorages are at the middle of length, the expansion each way, being one-half of the total, could be taken up by side spring of the branches which, in any case, should be of liberal lengths for that purpose.

Suitability of Well Water for Boiler Feeding—The water of a deep well on our premises, when first raised, presents a milky appearance. When a sample is allowed to stand in a clean glass vessel for about an hour, it becomes transparent. Do these properties signify that the water contains impurities that render it unsuitable for use as a boiler-feed? T. B.

The milky appearance of the water when first drawn from the well probably is due to small bubbles of carbonic-acid gas that may be observed by examination of the sample with a magnifying glass. When a sample of the water has become clarified by standing, add a small quantity of clear lime water, and if a milky appearance is reproduced it would indicate presence of CO_2 and probably presence of calcium carbonate that would be precipitated by heat, and likely to form a troublesome boiler scale unless some device is used for heating the water to 210 or 212 deg. F. for obtaining deposit of most of the carbonate before the water is fed to a boiler.

Ice Making Capacity of Refrigerating Plants—Why cannot I secure 20 tons of ice per day from a refrigerating plant rated at 20 tons of refrigeration? R. S. C.

One ton of refrigeration is the equivalent of the amount of cooling secured by the melting of one ton of ice. In melting at 32 degrees Fahrenheit a pound of ice takes up approximately 144 British thermal units. A ton of ice would then take up 2,000 × 144 or 288,000 B.t.u. If this is done in 24 hours the heat taken up per minute is 200 B.t.u. When ice is frozen in a refrigerating plant the water must first be cooled from the supply temperature, say 60 degrees F. to the freezing point of 32 deg. in temperature. The heat removed in cooling the water from 60 to 32 degrees F. is 28 B.t.u.; the heat lost by the water in freezing is 144 B.t.u. and if the ice is reduced in temperature to 16 degrees F. the total refrigeration done is 28 + 144 + 16 or 188 B.t.u. Under these conditions we could expect to secure only $\frac{144}{188}$ of the plant's ratings in actual tons of ice or 76 per cent. In the case given this would be 76 per cent of 20 tons or 15.2 tons of ice per day. In view of other heat losses by radiation, conduction, etc., the actual B.t.u. per pound of ice may reach 200 instead of 188 as given above.

Grounding Three-Phase Generators—In operating four 11,000-volt, 60-cycle three-phase star-connected turbo-alternators in parallel, with the neutral of the system grounded, which is considered better practice, to simultaneously ground the neutral points of all the generators, or of only one machine? R. N.

When any number of three-phase star-connected generators are operating in parallel, it is bad practice to ground more than one machine at the same time. The reason for this is that it is practically impossible to build two machines so nearly alike that they will generate exactly the same voltage between each terminal and the neutral. There are always slight differences, even between the different phases of one machine, due to unavoidable differences in pole strength and flux distribution. These differences are still more marked under load, on account of differences in winding resistance and reactance in the different phases. Therefore, when the terminals of two or more machines are tied together through the bus, their neutrals will practically never be at the same potential. If they are connected together, wattless current, which in some cases may be very large, will circulate through the neutral between the machines and cause unnecessary heating. The only advantage in grounding more than one generator at the same time would be to distribute between the different machines the short-circuit current resulting from a ground on one phase of the system. This advantage loses all value through the modern practice of grounding a station through a resistance that limits the possible short-circuit current to ground to a value well within the instantaneous capacity of one machine.

Setting Valve of Single-Valve Shaft-Governor Engine—What is the method of setting the valve of a single-valve shaft-governed engine? L. J. C.

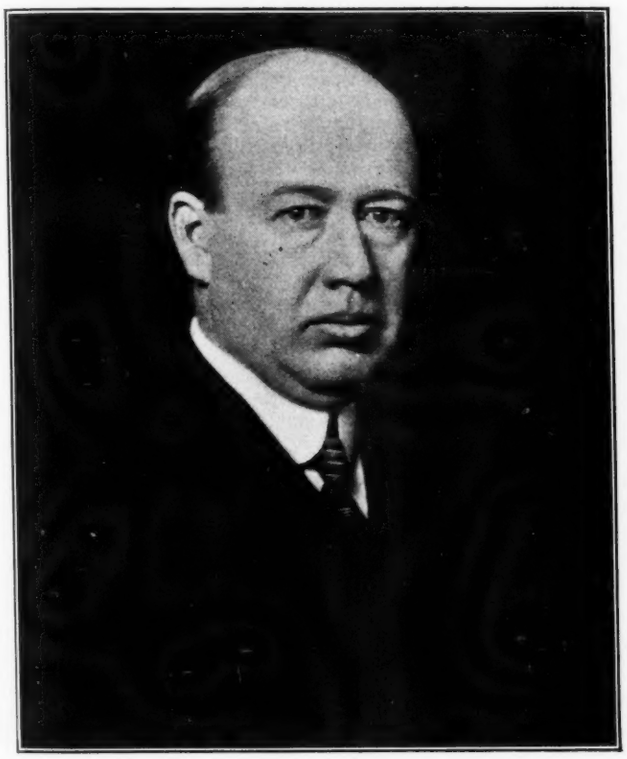
If the governor wheel is not keyed or otherwise fixed in proper position on the shaft, place the crank on a dead center and, with the governor wheel turned to various positions, move the weights in and out and set the wheel to a position for which movement of the weights causes no movement of the valve. When the governor wheel is fixed, turn the engine to place the piston in the head end of the cylinder with the crank at dead center and block out the governor weights to extreme position. Then adjust the length of the valve rod or its nearest connection so the valve will be at the point of just opening for admission of steam to the head end. Next, remove the governor blocking to allow the weights to move inward. If the valve is thereby moved, the valve gear gives variable lead and the setting is completed; but if the valve is not moved, adjust the valve to give about ⅛ inch lead. With most single-valve engines this will give a greater amount of lead on the crank end that will more nearly equalize the cutoffs. To test the equality of cutoffs, block out the governor to the average running position, determine the point of cutting-off for a stroke from each end of the cylinder, and adjust the valve to the desired equality of cutoffs. This generally introduces unequal leads, and in any case equality of cutoff must be sacrificed sufficiently to obtain some lead for each end. After the valve has been set for acceptable compromise of leads and cutoffs, the engine should be tested with highest working pressure to determine that the leads are not sufficient to cause the engine to race with no load.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

N. E. L. A. Considers Power Problems

Ways and Means of Meeting Necessary Expansion, Adequate Rates, Economical Generation and Improved Operating Practice

EMPHASIZING the necessity for systematic expansion in central-station systems to meet the growing industrial load, President Martin J. Insull opened the Forty-fourth Convention of the National Electric Light Association at Chicago on May 31. He estimated that in the next five years the electric light and power industry will require an expenditure of one billion dollars a year to meet adequately the demand. The present economic depression has not materially damaged the industry, in his opinion, because it does not have to stand large losses on invested property due to falling prices, as nearly all the investment is a fixed one and the amount of floating investment is small. In the plans for greater expansion economic generation must be the dominant factor, and many small uneconomical stations scattered over the country will necessarily have to be displaced by the large economical generating plants connected by extensive transmission and distribution systems.



M. R. BUMP
Newly Elected President, N. E. L. A.

Commenting upon the future expansion in the use of central-station power, Samuel J. Insull, president of the Commonwealth Edison Co., reviewed the large interconnected system with which he is associated, covering a vast area in the Middle West from St. Paul on the north and west to St. Louis and Louisville on the south, and compared this with the proposed Superpower System planned for the Boston-Washington area in the East. In his opinion high load factor is to be found in localities where there is a large kilowatt use per capita. In New York City there is an annual load factor of approximately 40 per cent with a per capita use of 400 kilowatts as compared with a load factor of 45 per cent in the Chicago district and a per capita use of 700 kilowatts. Moreover, the greater the territory served the greater will be the diversity of load. In planning new stations, the speaker urged the necessity of economic generation and predicted that when a whole section has been tied together only those plants will survive that are able to feed into the system economically.

Mr. Insull was concerned lest the superpower investigation now being made should savor of some Government control.

In discussing this point, W. S. Murray, chairman of the Superpower Committee, assured Mr. Insull that the investigation was first and last a public-utility matter. The Government had been approached merely in order to secure its backing and to assure the public of impartial results, and in the final analysis the proposed Superpower System will merely carry out to a higher degree what has already been carried on in certain other sections of the country.

The Superpower Committee's report would be ready by July 1, Mr. Murray predicted.

Public's Interest in Utility Development

James A. Perry, president of the National Association of Railway and Utility Commissioners, addressed the association on the relations of the public to the utility. He believed that much could be done by the local newspapers in presenting the truth of the utility business to the public. There are nearly a million and a half people, he said, who have money invested in utilities, and wherever adequate service is maintained there is usually little complaint about increased rates. New capital is necessary for the proper expansion of the utility business and in order to provide adequate service, and with the present high prices of money it is most necessary that regulatory commissions handle the utilities in such a way as to insure a return sufficient to attract the necessary capital. At present many of the utilities are not sufficiently strong financially to meet expansion, owing largely to the refusal of regulatory bodies to grant adequate rates.

Speaking along similar lines, E. I. Lewis, of the Interstate Commerce Commission, and formerly chairman of the Indiana Public Service Commission, pointed out that utility rates had not advanced with other commodities. On the other hand, they would not be likely to drop with commodities because of the necessity of meeting new demands of service, deferred maintenance and rehabilitation of properties. Moreover, operating expenses have not dropped along with commodities on account of coal prices and the freight rates entering into this item. In addition there is the factor of excessive local taxes.

By way of advice Mr. Lewis pointed out that utilities can relieve the regulatory commissions of many difficulties by frankly laying their cards on the table and through education and service gain the confidence of the public; this applies especially to the handling of complaints. Unfortunately, there are some utilities that will not go further than to meet their legal obligations, disregarding tact in dealing with the public, and in such cases the problem of the utility commissions is a difficult one.

Prime Movers

The sessions that proved of greatest interest to power-plant men were those of the Technical Section, and particularly that devoted to prime movers. The report of the Prime Movers Committee this year covered some 360 pages and reflected great credit on the work of the committee. As usual it was subdivided into the various component parts of a power plant and was supplemented by statements from the manufacturers.

Under the heading of "Turbines" the committee reported that the maximum size of single-cylinder units is still limited to 45,000 kw. and that there has been no appreciable change during the year in steam pressures and temperatures, although higher pressures and temperatures are a

possibility for future application. The trend of European practice seems to be toward higher speeds, higher superheats and higher pressures, in addition to a tendency toward standardization of performance, ratings and dimensions.

Turbine lubrication is receiving a great deal of attention. On account of the severity of conditions imposed by steam-turbine practice, the solution is difficult for both the turbine builder and the oil refiner. With regard to oil purification the continuous system and the continuous bypass appear most effective. Whatever method is used impurities should be removed continuously as they cause emulsification, sludging and acidity, which results in rapid deterioration of the oil.

A number of manufacturers are working on the development of a closed system of generator ventilation, in which the same body of air is constantly recirculated. The basic idea is to obtain cleaner air than can be had by washing free air and also to reduce fire hazard to a minimum.

Condensers

The regulation of the flow of circulating water to condensers, taking into account the seasonal variation in cooling-water temperature, is being considered by both the operating companies and the manufacturers. This scheme should reduce the power required for driving circulating pumps and will avoid lowering the condensate to a temperature below that corresponding to the vacuum.

Boilers, Superheaters and Economizers

The tendency toward larger units still continues, and reference was made to the four 26,470-sq.ft. boilers recently installed by the Ford Motor Co. Pressures and superheats are gradually being raised, although 300 to 350 lb. and total temperatures of 600 to 700 deg. seem to be as high as boiler designers are willing to go at present. Lack of knowledge of the properties of materials and of the possibilities of turbine design seem to limit the temperatures to these figures. Under these circumstances designers are considering the use of higher pressures without increasing the total temperature. The continued high cost of economizers has led boiler manufacturers to develop boilers with higher tube banks in order to get at least part of the volume that could be realized with an economizer. On horizontal-tube boilers there is a marked tendency toward the use of baffles inclined at an angle of less than 90 deg. The larger boiler units and the higher peak ratings with consequent fluctuations in the rate of steaming are giving turbine manufacturers concern, because of fluctuations in superheat and consequently in the temperature of turbine parts.

Stokers, Grates and Economizers

A marked activity in the improvement of stoker design has been noted during the last year. The successful application of forced draft to chain-grate and conveyor types of stokers is important, as it opens up to this type a field that has heretofore been held by the underfeed stoker. On the principle that the supply of coal and air are proportional to the rate of steaming, several manufacturers are offering systems that control stoker speeds and the speeds of fans and other auxiliaries through a master control actuated by differences in steam velocities. Also, various methods of preheating air for boiler furnaces have been proposed or adopted.

Relatively few changes have been made in the design of cast-iron economizers, but manufacturers of steel-tube economizers report many new developments. Also, considerable interest is being shown in the wrought-steel type on account of the higher boiler pressures now in use or contemplated. Corrosion, both internal and external, seems to be the most serious problem that now confronts the operator of economizer equipment. Internal corrosion is due largely to the presence of excessive oxygen and CO_2 in the feed water, and where trouble is being experienced from this source the water must be freed from these dissolved gases. External corrosion, on the other hand, is due largely to moisture condensing on the outside surface and combining with the sulphur compounds in the flue gases, forming sulphuric acid. The remedy is to raise the temperature of the inlet water to a point where condensation does not take place under conditions of steady boiler operation.

Auxiliaries and Station Piping

It is generally accepted that the most economical methods of maintaing heat balance in the larger stations are the house turbine in combination with a heater condenser and a straight electric drive with bleeding of the main units for feed-water heating.

The single-stage high-pressure feed pump for pressures up to 400 lb. has been developed in England with satisfactory results. However, American manufacturers with one or two exceptions still hold to the practice of limiting pressures to 100 lb. per stage.

A few years ago line welds were considered advisable in order to reduce the number of flanged joints, but experience indicates that they may be dangerously weak unless very carefully made. Investigation shows that autogenous butt-welded joints are too much affected by poor workmanship to be entirely satisfactory, although there are several types with reinforced sleeves that have proved amply strong under severe service.

Practically all stations using pressures above 200 lb. have standardized on steel-body gate valves with complete monel-metal trim. Many companies feel that separators and water traps on steam leads to turbines are not advisable and that it is better practice to try to prevent slugs of water leaving the boilers and to depend upon well-designed steam piping properly drained.

Fuels

Lack of expansion in the use of lignite is probably due to lack of knowledge of how to get the most efficient results from fuels of this type as well as to the storage difficulties.

Developments in the field of pulverized fuel indicate a continued interest on the part of engineers as to this method of burning coal, and very successful results have been obtained by the new Lakeside Plant of the Milwaukee Electric Railway and Light Co.

In connection with the burning of fuel oil, the committee reported that successful results require that boiler designs take into account many factors other than that of sufficient furnace volume; the type and location of baffles, location of burners, thickness and kind of refractories, and a number of other equally important considerations all have a marked effect on operating results. Mechanical burners, although long used in marine work, have only recently been employed to any great extent in stationary plants. It is claimed that they require very much less auxiliary steam than do the steam atomizing burners, a claim that seems well founded by the experience of a New England plant whose records for continuous operation over a six months' period show that only two-thirds of one per cent of the total steam was used by the mechanical burners.

Turbine Lubrication

Owing to time limitations discussion of the prime movers report was confined principally to turbine lubrication and powdered fuel versus stokers.

It was the consensus of opinion among several manufacturers' representatives and those of operating companies that there is very little definite information available on turbine lubrication. One large company had previously prescribed certain brands of oil, but soon discovered that it was much better to merely prescribe that the oil have certain qualities. It is believed that the investigation which the Prime Movers Committee is now making in conjunction with the Bureau of Standards will be productive of constructive results.

C. M. Larson, of the St. Clair Refining Co., was of the opinion that the best way to work out standard specifications would be for the committee to conduct research work much the same as the procedure followed in establishing specifications for automotive oils. This would mean that after the oils had passed the tentative specifications they would be tested on turbines hooked up to dynamometers. Samples of the new oil and the used oil, after various periods of operation, would be analyzed and the changes in

the characteristics plotted. By taking the frictional horsepower readings at regular intervals, as well as oil consumption, oil temperature, bearing temperature, etc., the data secured could be used as the basis for formulating final specifications. This procedure is absolutely necessary in order to get comparable data on the same unit under identical operating conditions with various oils. In the opinion of Mr. Larson specifications properly drawn up should eliminate fully 90 per cent of the unsuitable oils, but in order to choose from the remaining percentage of suitable oils service tests have to be resorted to. Also, in order to get minimum frictional losses the proper viscosity of the oils must be determined by service tests. In like manner must the wearing qualities or change in characteristics of the oil be determined.

The speaker was of the opinion that the specifications drawn up by the committee are too complicated for commercial work and require tests that are not commercially adopted as standard. Specifications to be used by power-plant operators should be broad, yet not so complicated that the tests could not be properly handled by the average well-equipped laboratory. With this point in mind it would seem that specifications covering the flash-point viscosity, color, pour, emulsion, acidity and corrosion tests, would adequately fill the requirements, as experience has shown that oils meeting these tests will handle turbine lubrication satisfactorily.

The degree of service that can be obtained from any high-grade oil meeting the prescribed specifications depends largely upon factors of operation. It has been found that an oil that is exposed to air during circulation will oxidize more rapidly than one that is passed on to the bearings and back through the cooling and filtration system in as nearly a solid stream as possible; also too rapid cooling of the oil over too great a range with the further heating by friction of the bearings, tends to cause fatigue or rapid breaking down of the oil. Attempts have been made to overcome this by the use of oil instead of water in the coolers, based on the fact that specific heat of the oil is lower than that of water. Oil cooling has the added advantage in that any leakage would allow oil to leak in rather than water. This method seems to be gaining favor. Extreme care should be exercised to keep water out of the system whether it be leakage from the glands or the oil cooler.

W. H. Herschel, of the Bureau of Standards, was of the opinion that the greatest difficulty with turbine oils is sludging; therefore there should be an oxidation test. This should not be confused with a carbon test as made with automotive oils, which is merely a residual test. A fractional distillation test should be supplementary to an oxidation test. The flash point is of little use, as it gives no indication of the percentage of the light fraction that is present and no evaporation test has thus far been made standard.

C. H. Bromley, of the Richardson-Phoenix Co., believed that there is a reluctance to use a large enough volume of oil. Where large volumes of oil are used the life of the oil is materially lengthened.

Powdered Fuel vs. Stokers

John Anderson told of the satisfactory results that are being attained with the powdered-fuel installation at the new Lakeside Plant of the Milwaukee Electric Light and Railway Co. At 137 per cent rating a boiler efficiency of 85.6 was attained, or an efficiency of economizer and boiler of 90.2 per cent with 16 per cent CO_2; at 214 and 235 per cent rating the respective boiler efficiencies were 82.5 and 80.5 per cent, the boiler and economizer efficiencies 87 and 86 per cent, respectively, and the CO_2 was 14.7 and 14.5 per cent. This was with coal averaging about 11,600 B.t.u. as fired, running to 12 per cent ash and 4 per cent moisture. The power required for preparation of the coal was equivalent to 51 lb. of coal per ton prepared, or about 2½ per cent. Mr. Anderson estimated the labor and material for pulverizing as about 10 cents per ton. At this plant the air is preheated by drawing it in through the furnace walls; 65 per cent of the air is thus preheated to temperatures ranging from 300 to 700 deg., 15 per cent is drawn in with the coal and 20 per cent around the burners. Extreme flexibility in quickly handling peak loads has been experienced at this plant.

About fifty members of the Association visited the plant as the guest of Mr. Anderson on Friday, where many of Mr. Anderson's statements were demonstrated, much to the interest of those present.

W. J. Santmyer, of the Puget Sound Light and Power Co., spoke of the success which his company has had in handling low-grade, high-ash and high-moisture coal in powdered form under boilers, the ash running from 16 to 22 per cent and the moisture as high as 28 per cent. Mr. Santmyer most emphatically defended powdered fuel against the attacks of the advocates of the stoker.

Joseph Harrington took up the defense of the stoker, and while admitting the efficiency claimed for powdered fuel, believed that the final answer was the cost per kilowatt at the busbar. In this connection he believed the stoker showed up as well as, if not better than, powdered fuel, inasmuch as the pulverizing equipment adds materially to the complication of the plant. He questioned whether it pays to pulverize the inert matter; the cost of pulverizing per pound of combustible gas goes up as the ash increases, and he did not believe it pays to pulverize coal running above 15 per cent ash. He contended that the only fair comparison between the two methods of burning coal should be made with the most up-to-date type of stoker, which can now burn any grade of coal at any capacity without loss in efficiency. Furnace temperatures are a limitation with powdered fuel on account of deterioration of the brickwork, and this limits the excess air. In the final analysis he believed that powdered fuel is applicable to certain cases and inapplicable in others, but that it should be applied only with full regard to its limitations as touched upon in his discussion.

Electrical Apparatuus

With the new plan of divisional organization in effect, which co-ordinated splendidly with the geographic division organization of the association, the Electrical Apparatus Committee did excellent work and had a valuable report to show for it. In its presentation Chairman **R. F. Schuchardt** presided. In co-operation with other organizations much was done toward standardization, special efforts being directed to secure the standardization of service voltage, with a leaning toward 115 volts as the preferred standard. The generating-station subcommittee recounted experiences with fire-fighting equipment and generator relays, described a closed-circuit ventilating scheme to limit the amount of oxygen available to support a generator fire, outlined a recent departure in switchhouse design for large stations and discussed problems relating to electrical drive for auxiliaries. The need of strengthening the mechanical design of reactors was emphasized and the desirability of using shunting resistors with them was brought out in several contributions grouped into an appendix. Under transformers the use of a fire-fighting system similar to oil-company methods was discussed. Progress was reported in automatic substations and synchronous converters and mention made of the development abroad of iron-tank mercury arc rectifiers. As in past years the committee reviewed the development in electrical application in various industrial fields, attention in the present report being devoted to wood working, pulp and paper making, electric furnaces, textile mills and a number of other applications.

The discussion following the report brought out the fact that there was no occasion for the low power factors imposed by induction motors under average operating conditions, provided they were properly compensated with static condensers. As a power factor much nearer unity was desirable, a resolution was introduced requesting that the incoming committee be instructed to address manufacturers of induction motors with a view to induce them to so equip all new motors.

Use of an inert gas in a closed system of generator ventilation was not favored, as in service the leakage of air into the system would make uncertain the proportion of gas remaining. Using CO_2 to smother the fire instead of water would save the time required to dry out wind-

ings. Opening-circuiting of temperature resistance coils in generators was a trouble that had been experienced on certain occasions.

Hydraulic Power

In the first year of its existence the Hydraulic Power Committee necessarily spent much time in organization and in the preparation of a comprehensive outline forming the basis for future work. The importance of study in this field was made evident by statistics showing that of the total energy generated in public utility power plants in the United States during the year 1920 steam power produced 62 per cent and water power 38 per cent. In five of the thirteen geographic divisions of the association, water power predominated in the generation of electrical energy. At the present less than 17 per cent of the total potential water power had been developed.

An excellent groundwork for the future was provided by preparing a synopsis of what had been done in previous years by the Technical Section, a bibliography of selected articles and an outline of subjects to investigate under the broad heads of "General Problems," relating to water supply, regulations, etc.; "Design and Construction," covering hydraulic works and generating stations; "Operating Procedure"; "Maintenance Data and Methods," and "Tests." In the technical session of the report brief reference was made to progress in the design of waterwheels, draft tubes and of the new types of fall increasers developed recently to minimize reduction in head from the tailwater rising during the flood discharge of streams. General problems such as the determination of rainfall and stream flow, evaporation and the prediction of water supply were given attention and considerable space devoted to operation for maximum economy at the Keokuk hydro-electric plant.

In the discussion R. J. C. Wood referred to the satisfactory operation being obtained from the Kern River Plant No. 3, where two 22,500-hp. reaction turbines, subject to a head of 800 ft., had been installed. The chemical method of measuring the flow through the turbine had been rejected, as estimates showed that it would require eight tons of salt. The bursting plate as a safety device was of little use, for if it did not happen to be placed at the point of rupture the high-pressure wave would never reach the plate before the damage was done. That part of the report dealing with the measurement of runoff did not take into account the storage of water in gravel. In California this factor was of considerable importance. They had noticed a close relationship between ocean temperatures and precipitation in the immediate vicinity. This ocean factor, however, did not apply over a wide range of territory.

Mr. Tefft enlarged upon the subject matter in the report dealing with his conduit spillway, which consists of conduits underneath the power house, taking water usually from behind the racks and discharging it into the draft tubes. The advantages claimed are cheapness of construction, control of spillway valves from the generator room, immunity from freezing, location of valves and operating mechanism favorable to inspection, cleaning effect in the tailrace and a considerable head increaser effect.

Experience with four 7-ft. penstocks under a head of 375 ft., two of redwood staves and two of steel, had convinced Mr. Ross, of Duluth, that the former would not last indefinitely. The ends of the staves at the joints would split and by projecting inward increase the friction offered to the flow. With the steel flumes corrosion was troublesome, but could be minimized by painting over an absolutely clean surface. Collection of slime within the penstock had been prevented by the application of creosote under vacuum.

John A. Britten spoke of the remarkable Pit River, in which the flow is practically constant, the variation not exceeding 10 per cent, and the 500,000-hp. chain of eight plants now projected or under erection on this river and its tributaries. The flow was 1,500 sec.-ft. which was increased by the tributaries to 2,500 sec.-ft., representing the amount of water that might be drawn from a storage of 20 million acre-feet. Films showing the construction work on two of these plants were presented by Mr. Downing. Commenting upon the possibilities of the coast, Mr. Britten stated that California has 9,000,000 potential water horsepower, of which a little over a million has been developed. The coast has all the minerals and raw materials necessary to industry and he believed a few years would see that section a center of manufacturing.

Eugene Vinet called attention to the reverse relation of steam and water power in Canada, where 86 per cent of the power was developed by water and 14 per cent by steam. Of the available water power of 10 to 12 million horsepower, about 2 million had been developed. There were many favorable sites, mention being made specifically of Montreal and Queenstown Heights. Cold weather and ice were the chief sources of trouble.

Conjunctional Operation of Central Stations and Isolated Plants

The Report of the Power Sales Bureau devoted considerable study to the conjunctional operation of central stations and isolated plants, reviewing the plan which has been in operation for some time by the Edison Electric Illuminating Co. of Boston. Here secondary service is that in which the customer has a source of hydro-electric power, steam or other supply which during the year operates at capacity sufficient to supply the customer's maximum demand at least a number of kilowatt-hours equivalent to a minimum of 200 times the customer's maximum demand, or at least 10,000,000 kw.-hr.; and where the service is supplied solely at the convenience of the company.

The sale of conjunctional service, at special rates, with restricted hours of use and of available service is based upon the premises that this class of business presumes the use of service at times when the central station has a surplus of generating and distribution capacity, and that the customer cannot, because of his peculiar operating conditions, afford to purchase all year service.

Although the central station may not be able to compete with these plants for year-around service it will usually be found that during certain portions of the year it can compete and thereby derive a very considerable income. The factors which prevent the central station from competing with year-around service for certain isolated plants are various combinations of the following conditions: (1) Undepreciated electric plants; (2) hydraulic elevators; (3) live steam for appliances; (4) engineers' service required for repair work; (5) unusual steam-heating requirements; (6) expense of central station connection; (7) the desire to remain independent.

When a combination of these factors prevents the central station from competing throughout the year, it has been found that the secondary service connection for the non-heating season will prove an economy.

Co-ordination or co-operative operation of the private plant with the central-station service offers the following advantages: (1) A duplicate source of power for the greater part of the year; (2) a convenience at night, Sundays and holidays throughout the year; (3) saves boiler-feed water at a time when condensation is not possible in the heating system; (4) the double-throw switch is a practical antidote for engine and boiler-room labor difficulties; (5) reduces the work of the fireman; (6) gives the engineers an opportunity to repair their equipment and to take a summer vacation free; (7) intimate working knowledge of central-station service and basis of comparison of the quality and flexibility of purchased power as compared with isolated plant generation.

G. E. Miller, of the Cleveland Electric Illuminating Co., and I. Lundgaard, of Rochester, discussed the experiences of their companies in supplying such service, it having been particularly favorable in Rochester.

At the final session of the convention M. R. Bump was elected president for the ensuing year. The other officers elected are Frank W. Smith, first vice president, W. H. Johnson, second vice president, Franklin T. Griffith, third vice president, J. E. Davidson, fourth vice president, and H. C. Abell, treasurer. The new president is chief engineer of the Henry L. Doherty & Co., and is well known in utility circles.

The committee on membership reported that on April 30, 1921, there were 11,106 members of the association as compared with 9,671, a gain of 1,489 during the year.

American Engineering Council Holds Important Meeting

At the June 3 meeting of American Engineering Council in St. Louis there were some developments of rather more than usual importance, including, principally the presentation of the report on Elimination of Waste in Industry.

The report is one of the biggest undertakings so far attempted by the Federated American Engineering Societies (of which the Council is the governing board) and has been prepared by a committee that was appointed by Mr. Hoover on Jan. 12 before his resignation as president of the federation. The personnel of this committee is remarkable for the number of nationally prominent men included, as may be seen from the following list of its members: J. Parke Channing, New York, chairman; L. W. Wallace, New York, vice-chairman; Herbert Hoover, Washington; L. P. Alford, New York; George D. Babcock, Syracuse; F. G. Coburn, Philadelphia; Morris L. Cooke, Philadelphia; Harrington Emerson, New York; Ira N. Hollis, Worcester, Mass.; E. E. Hunt, Washington; C. E. Knoeppel, New York; Robert Lunton, New York; Fred J. Miller, New York; H. R. V. Scheel, Passaic, N. J.; J. H. Williams, New York; Robert B. Wolff, New York.

The purpose of compiling this report was to secure definite and complete information on the various wastes in industry to serve as a starting point for, and to show the need of a nation-wide effort toward the elimination of industrial waste. Originally, ten typical industries were selected for examination, but the present report, which is preliminary in nature, covers only the following five: Housing and building, men's ready-made clothing, shoes, metal trades and printing. Some of the remaining five industries, however, including bituminous coal, will be taken up in later reports.

In carrying on this work it has been explained that the idea has been not to hold up any one industry to public censure, but to get at the actual facts in the case—the definite and measurable wastes in typical industries, which result from methods that can be more intelligently corrected when their effects are made known. The committee has, therefore, avoided abnormal conditions such as have been caused by the war and has collected data only where the situation has been normal and representative of American industry as a whole.

The report was not approved by the council, but was referred back to the committee with instructions to revise it in certain respects and then to issue it to the public. The following comments upon it and excerpts from it will serve to give an idea of its scope and of the extent of industrial waste that it reveals.

The investigation found that the margin of unemployment mounts to more than a million men, that billions of dollars are tied up in idle equipment, that high labor turnover is a rough index of one of the commonest wastes, and that the waste of time and energy and money through duplications and estimates and bids in the building trades runs into millions annually.

Both employer and employee restrict output, it was said. Both capital and labor are blamed for existing abuses, but the annual losses through waste by conflicts between them is much less than popularly supposed. Between four and five million workers were idle during January and February of this year, and in 1921 half a billion dollars will be lost in wages in the building trades. Nation-wide machinery to obtain continuous information concerning unemployment conditions throughout the country and means for regularizing employment in the principal industries are proposed as remedies. An elaborate plan of nation-wide co-operation between the government, the public, trade associations, the industries, labor, bankers and engineers is outlined.

"Waste," according to the report, "results from an interruption of production, low production, restriction of production and lost production." The wastes of interrupted production, it is said, result from idle men, materials, plant and equipment.

As to restricted production the report says:

"Both employer and employees restrict output, the former usually by limiting the total output of an industry, the latter by limiting the rate of speed of output of individual workmen."

Ill health and industrial accidents figure in the causes of lost production, the findings as to which are summarized as follows:

The economic loss in this country annually from preventable diseases and death is over $3,000,000,000; 42,000,000 persons gainfully employed lose 350,000,000 days from illness and disease and non-industrial accidents annually; 42 per cent of the wastes of ill health is preventable. In 1919 there occurred in industry 3,000,000 accidents resulting in an economic loss to the country of about $853,000,000; industrial accidents are caused by the carelessness of the workmen and a lack of ordinary safeguards; authorities agree that it is possible by using methods already perfected, to reduce deaths and serious accidents in American industry by at least 75 per cent.

The committee offers recommendations for the elimination of waste in production and outlines the following proposed program of governmental assistance:

A National Industrial Information Service should be established to furnish more timely, regular and complete information covering current production and consumption and stocks of commodity; a National Statistical Service should be established covering employment requirements; a national policy regarding public health should be fostered and encouraged; the material program for industrial rehabilitation should be encouraged and should offer opportunities for education and placement to those having physical defects as well as those handicapped because of industrial accidents; a nationwide program of industrial standardization should be encouraged in conjunction with industrial interests; the government should recognize the necessity for a revision of such federal laws as interfere with stabilization of industry; a body of principles should be accepted which could be developed for the adjustment and settlement of labor disputes.

The building industry was said to be about 60 per cent efficient. In the shoe industry the waste is put at about 35 per cent. The average plant in the metal trades group is from 25 per cent to 30 per cent behind the best plant in output per employee.

At this meeting of the council there was considerable discussion as to whether or not a new president should be chosen in the near future to take the place of Mr. Hoover, the final decision being that nomination blanks be sent out for an election to be held at the fall meeting of the executive committee.

On advice of a committee that had been appointed to consider action in regard to the Federal Power Commission it was decided that the matter should be dropped.

The time and place of the council's next meeting are to be fixed by the Committee on Procedure; it is thought that the date chosen will probably be some time in September.

Coosa River Development

The Alabama Power Co.'s project, a license for which was authorized by the Power Commission May 20, covers a power development in the Coosa River at Duncan's Riffle, Ala. The plant will be located below the company's present plant at Lock 12 and will be a part of its power system.

A concrete dam will be built having an elevation at the crest of approximately 335 ft., with Taintor gates to raise the pool elevation to approximately 350 ft., creating a pool elevation to the extent of a tail-water on Lock 12. The power house will be an integral part of the dam and will have provision for an ultimate installation of five units. The initial installation will be two units, each having a capacity of 24,000 hp. The transmission line will carry 110,000 volts and extend from the proposed plant to the company's existing plant at Lock 12, there connecting with the existing transmission system of the company.

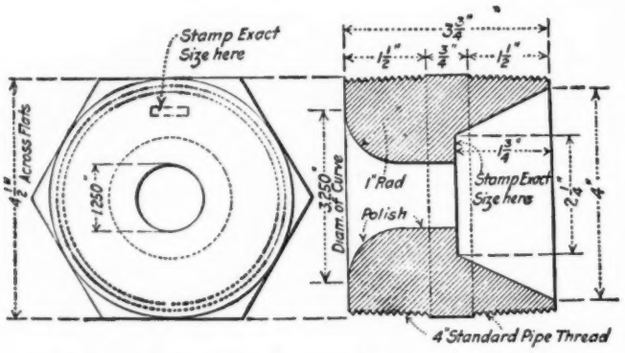
The license will provide that work must be started on or before Sept. 1 and shall be completed before Sept. 1, 1924, except for the installation of three power units, which will not take place until such time as a market for the additional power develops.

Dry Vacuum Pump Capacity Tests*

By Snowden B. Redfield†

A dry vacuum pump is only a compressor working through a range of pressure low down on the scale. Every compressor is really a "booster"; that is, it takes in its air or gas at one pressure and compresses and delivers it at a higher pressure. The intake may be at any pressure below atmosphere, exactly at atmosphere, or even a hundred or more pounds above atmosphere. Similarly the discharge pressure may be anything, as long as it is above the intake pressure. In all cases the cycle of intake compression and discharge is essentially similar, although the weight of material and the power required will vary widely, according to the pressure.

A word should be said in explanation of the terms "low-pressure nozzle" and "high-pressure nozzle." These are the popular terms to designate whether the back pressure into which the nozzle is discharging is above the critical pressure or below it, respectively. The critical back pressure for air is 0.53 of the upstream or initial pressure, and if the back pressure is above the critical, the expansion



CONVENIENT FORM OF AIR-MEASURING NOZZLE

ratio is relatively low, so the nozzle may be called "low pressure." If, on the contrary, the back pressure is less than the critical, the total expansion ratio is relatively high and the nozzle is said to be a "high-pressure" nozzle. The accompanying table gives the class of nozzle for various pressure ratios, assuming a 30-in. barometer.

Owing to the excessive noise of a "high-pressure" nozzle and the inaccuracies and difficulty of reading pressure gages of the spring type the low-pressure nozzle with water-

CLASSIFICATION OF NOZZLES FOR AIR MEASUREMENT

	Upstream Pressure		Back Pressure		Ratio of Back Pressure to Upstream Pressure	Kind of Nozzle
	Gage	Abs.	Gage	Abs.		
For pressure work.....	100	114.7	Atm.	14.7	0.128	High-pressure
	20	34.7	Atm.	14.7	0.424	High-pressure
	12	26.7	Atm.	14.7	0.551	Low-pressure
	2	16.7	Atm.	14.7	0.880	Low-pressure
For vacuum work.....	Atm.	14.7	2-in. vac.	13.75	0.933	Low-pressure
	Atm.	14.7	8-in. vac.	10.80	0.733	Low-pressure
	Atm.	14.7	15-in. vac.	7.36	0.500	High-pressure
	Atm.	14.7	26-in. vac.	1.964	0.133	High-pressure
	Atm.	14.7	28-in. vac.	0.982	0.066	High-pressure

column pressure gage has been adopted by most of the leading compressor builders and is being incorporated into the new test codes of the society now under revision.

After a discussion of the apparatus used, formulas for calculating flow quantities, method of plotting test results, etc., the author gives the design shown in the sketch as a convenient form of nozzle. It is made with a pipe thread on both ends so that it can be used at will on the intake side of a vacuum pipe or on the discharge side of a compressor. The approach surfaces may have a radius of anything from 0.6 of the throat diameter upward, with inappreciable effect upon the co-efficient. The throat is followed by a straight or cylindrical portion. It is recommended that this be not less than one-quarter the diameter of the throat, and it may probably be as long as the diameter without affecting the coefficient. Anything longer might bring in an additional friction influence to reduce the coefficient very slightly. A short straight portion has been found really essential to secure smooth flow.

*Abstract of paper presented at Chicago, Ill., May 24, 1921, before the American Society of Mechanical Engineers.

†Engineer in charge, Easton, Pa., Engineering Department, Ingersoll-Rand Company.

Looking into the Cylinder of a Gasoline Engine in Operation

The first tool used by the investigator is usually the eye. He sees a thing happen, and the first step in his investigation is likely to be the obtaining of a telescope, microscope or something to enable him to see more clearly.

In the development of the internal-combustion engine, however, visual observation of the combustion has played a minor role. To be sure, early investigators did provide apparatus that permitted them to look in the cylinder while the engine was operating, but little has been done in this direction with engines operating at the high speeds of the present-day automobile types. Interest has centered in what an engine could do rather than how it did it. As a result, measurements of brake horsepower and fuel consumption have been deemed of first importance.

At the present time the cry for fuel conservation has reawakened interest in the nature of the combustion in the cylinder. Glass induction systems have disclosed how satisfactorily, more often how unsatisfactorily, the fuel has been prepared for combustion. Analyses of the exhaust gases have shown how completely, more often how incompletely, the charge has been burned. Admitting that it is important to study the preparation of the fuel for combustion and the results that are evident after it has taken place, an actual study of conditions during combustion should surely be worth while.

This has been accomplished in connection with the study of combustion in the one-cylinder Liberty engine at the Bureau of Standards in the following manner: A spark-plug shell has been adapted to receive a circular section of glass intended to serve as a window in the cylinder. This assembly can be used in place of either spark plug in the ordinary aviation cylinder, but in this instance an additional boss has been welded to the cylinder in order that conditions might be observed with both plugs firing. Its use was satisfactory in that changes in flame color due to changes in air-fuel ratio were easily discovered. Since the entire combustion stroke is completed in one-sixteenth of a second at an engine speed of 1,800 r.p.m., it is possible to see only the predominant color of the cycle by this means.

To make it possible to observe the combustion in its various stages, another device, a stroboscopic disk, was added. Its purpose is to permit the combustion to be observed only a small portion of the stroke. Since there is one power stroke for every two revolutions of the crankshaft, this disk is driven at one-half crankshaft speed. The flame is observed through a slot in the disk, the length of the slot governing the length of the portion of the stroke studied. Provision is made for altering the angular relation of this slot to the crankshaft so that any interval of the cycle, and, hence, any stage of combustion can be studied.

Observations made possible by this apparatus are not likely to replace any of the more usual measurements. They may, however, prove, and in fact have proved, of considerable value in research work of the nature described by permitting observations of the duration of luminous flame during the power stroke, the characteristic differences in color and brightness at different phases of combustion and their variation with changes in ignition timing, mixture ratio, compression pressure, etc. One observes, for instance, excessively bright flashes of flame of extremely short duration accompanying the phenomenon known as fuel knock, or detonation. The cause for this phenomenon is, of course, not revealed by usual observation.—*Bureau of Standards.*

Personals

Milton C. Hartman, consulting engineer, has moved his office to 25 East Jackson Blvd., Chicago.

J. R. Cravath has been elected president of the Pioneer Electric Co., electrical engineers and contractors, of Richmond, Cal.

F. J. Foote has been promoted from the position of master mechanic to that of superintendent of power with the Ohio Electric Railway Co., Springfield, Ohio.

R. S. Daniels has left the Washington Water Power Co., of Spokane, after fifteen years with them, and has taken a position as assistant to the chief engineer of the California-Oregon Power Co., of San Francisco.

Frank Sawford has opened an office at 609 Credit Foncier Building, Vancouver, as a consulting and constructing mechanical and electrical engineer, specializing in industrial power plants. He was formerly chief engineer of the Taylor Engineering Co., Ltd.

Society Affairs

The Engineers' Club of Philadelphia has announced the election of the following officers: President, William F. James; vice president, C. N. Lauer; treasurer, Clayton W. Pike; directors-at-large, Herbert B. Allen, Harry F. Sanville.

The Philadelphia Sections of the American Institute of Electrical Engineers, the American Society of Mechanical Engineers and the Illuminating Engineering Society will meet in a "Field Day," with baseball, golf and tennis, June 17, at Howard McCall Field, Highland Park, Pa.

The Army Ordnance Association has invited all those who served as officers in the Ordnance Department during the war and all who are interested in ordnance as a factor in preparedness to attend a meeting at the Engineering Societies Building, New York City, at 8 p.m., June 15, at which it is planned to form a local organization of the Army Ordnance Association in the New York Metropolitan district.

Business Items

The Crocker-Wheeler Co. has moved its Syracuse (N. Y.) office to 23½ West Swan St.

Smith, McCrory & Co., Inc., have opened advertising agency offices at 468 College Ave., Racine, Wis.

The C. H. Wheeler Manufacturing Co., of Philadelphia, manufacturer of condensers pumps, etc., has opened a new branch office at 53 State St., Boston, Mass.

The Ohio Brass Co. has transferred L. L. Wilkinson from New York to Philadelphia as district sales manager, with offices at 710 Witherspoon Building.

The Chuse Engine and Manufacturing Co. has moved its branch office from 408 Union Building, Cleveland, to 1217 Merchants Bank Building, Indianapolis, Ind.

The Combustion Engineering Corporation has secured larger quarters for its Philadelphia office in the Finance Building. The Philadelphia territory is under the management of W. C. Stripe.

Arthur D. Little, Inc., Cambridge, Mass., has announced the selection of Chester M. Clark, formerly head of the corporation department of Stone & Webster, as the new treasurer, and Merton P. Sumner, previously chief engineer of the Fuller Industrial Engineering Corporation, as chief engineer.

The J. F. Davis & Sons Co., 1122-4 Harris Trust Building, Chicago, has been organized by J. F. Davis, who is president of the company and whose son, J. E. Davis, is secretary. The entire plant, site, machinery and equipment of the De Pere Manufacturing Co. at West De Pere, Wis., has been bought by the new company, which will specialize on fire-tube boilers, tanks, special steel-plate construction and fabrication.

Trade Catalogs

The Ohio Brass Co., Mansfield, Ohio, is sending out catalog No. 52, a 6 x 9-in., 94-page booklet on its complete line of "O. B. Valves."

The Celite Products Co., 11 Broadway, New York City, has prepared an interesting catalog in the form of an 8 x 11-in. loose-leaf folder containing charts, tables, graphs, photographs and diagrams dealing with the flow of heat through furnace walls, thermal conductivities of brick, etc. The company's product is "Sil-O-Cel," an insulating brick used in boiler settings, coke-ovens, electric furnaces and for many other purposes.

The M. W. Kellogg Co., 90 West St., New York City, has prepared an unusually comprehensive 7¼ x 10½-in., 130-page catalog, "Power Plant Piping." It contains a large number of photographs illustrating interesting installations and numerous tables and charts, such as those on saturated and superheated steam, loss of head in pipe by friction, equation of pipes, etc. The general subject of power plant piping is covered so thoroughly and illustrated so clearly that the book undoubtedly has considerable educational value.

FUEL PRICES

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine-run basis, f.o.b. mines):

Coal	Market Quoting	May 31 1921	June 7 1921
Pool 1,	New York	$3.35	$3.25@3.75
Pocahontas,	Columbus	3.50	3.00@3.60
Clearfield,	Boston	2.35	1.85@2.80
Somerset,	Boston	2.95	2.60@3.25
Pittsburgh,	Pittsburgh	1.95	1.85@2.00
Kanawha,	Columbus	2.25	2.25
Hocking,	Columbus	2.25	2.00@2.25
Pittsburgh No. 8	Cleveland	2.25	2.20@2.40
Franklin, Ill.,	Chicago	3.00	2.60@3.50
Central, Ill.,	Chicago	2.40	2.25@2.75
Ird. 4th vein,	Chicago	2.90	2.25@3.00
Standard,	St. Louis	1.75	1.65@1.90
West Ky.,	Louisville	2.10	1.75@2.45
Big Seam,	Birmingham	2.95	2.35@2.85
S. E. Ky.,	Louisville	2.40	2.00@2.65

DIESEL FUEL OIL

New York—On June 1, Port Arthur light oil, 23@25 deg. Baumé, 4⅞c. per gal. 30@35 deg., 6c. per gal. f.o.b. Bayonne, N Y

Chicago—May 28, for 24@28 deg Baumé, 55@55c. per bbl.; 32@34 deg., 2@2¼c. per gal. In tank cars f.o.b. Oklahoma refinery, or freight adjusted.

St. Louis—June 4, prices f.o.b. cars, tank lots; 24@26 deg. Baumé, 50c. per bbl.; 26@28 deg., 55c.; 28@30 deg., 60c.; 32@34 deg. 2c. per gal.

Baltimore—On April 23, f.o.b. refinery; in tank-car lots; 24+ deg. Baumè, 6¼c.; 26@28 deg., 6¾c.; 30@34 deg., 7⅜c.; 14+ deg., $1.95 per bbl..; 16@20 deg., $1.85 per bbl.

Pittsburgh—On June 6, f.o.b. refinery; Pennsylvania, 36@40 deg., 3⅜c. per gal.; Oklahoma, 24@30 deg., 50c. per bbl., gas oil, 32@34 deg., 2c. per gal., 36@38 deg., 2¼c. 38@40 deg. 2½c.

Philadelphia—On June 6, 26@28 deg. Baumé, Oklahoma, 4⅜c. per gal.; 30@34 deg., Oklahoma (group 3) 2½c. per gal.

Cincinnati—May 28, for 22@28 deg. Baumé, 6⅝c. per gal.

Cleveland—May 28, for 22@28 deg. Baume, 5½c. per gal.

New Construction

PROPOSED WORK

N. H., Bennington—The Monadnock Paper Mills plans to build a 1 story hydro electric power station. About $100,000.

Mass., Great Barrington—The Southern Berkshire Power & Electric Co. plans to build a dam, etc, on the Housatonic River here. About $150,000.

N. Y., New York (Borough of Manhattan)—The Bd. of Purchase, Municipal Bldg., will receive bids until June 16 for furnishing and delivering a marine feed pump to the Dept. of Plant and Structures.

N. Y., Tarrytown—The Bd. Educ. plans to build a high school. About $500,000. Guilbert & Betelle, 2 Lombardi St., Newark, N. J., Archts. and Engrs.

N. J., New Brunswick—The State received bids for the installation of a heating system in the proposed ceramic building here, from Buist, Lane & Richardson, $5,467; Fred Merkel, 131 South 12th St., Newark, $5,725; J. H. Nelles Co., New York, $5,943.

Pa., Chester—The St. James R. C. Hospital is having plans prepared for a 3 story, 48 x 150 ft. hospital. About $400,000. F. F. Durang, 1220 Locust St., Philadelphia, Archt.

Pa., Merion—The Sisters of Mercy, Merion Academy, are having plans prepared for a 3 story, 140 x 200 ft. boys' dormitory building. About $650,000. F. F. Durang, 1220 Locust St., Philadelphia, Archt.

Pa., Scranton—The Bd. Educ. plans to build a high school. About $500,000. Guilbert & Bettelle, 2 Lombardi St., Newark, N. J., Archts. & Engrs.

Md., Baltimore—The Holtite Mfg. Co., Inc., 919 East Baltimore St., is in the market for a 50 hp. return tubular boiler.

Md., Baltimore—The Raisin Monumental Co., Natl. Marine Bank Bldg., is having preliminary plans prepared for a fertilizer plant on Fairfield St. About $1,000,000.

D. C., Washington—A. L. Flint, General Purchasing Officer of the Panama Canal, will receive bids until June 23 for 1 electric, 15 hp., 3 phase, 25 cycle, 220 volt, 1,500 r.p.m. motor and a water cooled, single stage, 5½ hp., rotary vacuum pump.

N. C., Kinston—The city plans to build a school. About $900,000. Architect not yet selected.

Fla., Wauchula—J. G. Fancy & Associates, Ft. Meade, plans to build an electric and ice and cold storage plant, here. About $50,000.

Tenn., Martin—The city, c/o G. P. Hirt, is having plans prepared for a 70 x 100 ft. electric light plant. F. L. Wilcox, Syndicate Trust Bldg., St. Louis, Engr.

O., Cleveland—The Bd. Educ., East 6th St. and Rockwell Ave., will receive bids until June 27 for a 3 story, 40 x 140 ft. high school addition on Parkwood Drive and Everton Ave. About $400,000 M. R. McCormack, Archt.

O., Cleveland—The city received bids for electric work in the new city hospital buildings from the Progressive Electric & Eng. Co., 2047 West 14th St., $115,000; Martien Electric Co., Illuminating Bldg., $122,698; J. Livingston Co., Sloan Bldg., $123,641.

O., Cleveland—The Naval Reserves of Cuyahoga Co., c/o T. B. Bolton, Commander, plans to build a 3 story naval armory on East 9th St. and Lakeside Ave. About $400,000. Lieut. C. W. Clark, c/o Armory, Carnegie Ave., Archt.

O., Cleveland—The Upco Co., 4805 Lexington Ave., is in the market for a 10 hp., a.c., 3 phase, 60 cycle, 200 volt motor.

O., Conneaut—The Bd. Educ. received bids for a 3 story junior high school including a steam heating system from the Kilpatrick Co., Pittsburgh, Pa., $294,215; Prahl Constr. Co., Erie, Pa., $306,275.

O., Elyria—The city will soon award contract for a 1 story pumping station and filtration plant including equipment. About $750,000. H. A. Beck, Dir. of Pub. Serv. M. Knowles, Inc., Pittsburgh, Pa., Archt. and Engr.

O., Lindhurst (Cleveland P. O.)—The Bd. Educ. will receive bids until June 25 for installing a heating, ventilating and plumbing system in the proposed school building, here About $25,000. E. J. Thom, Clk. F. C. Warner, 767 Hippodrome Annex Bldg., Cleveland, Archt.

O., Maple Heights (Bedford P. O.)—The Bd. Educ. will receive bids until June 24 for installing a heating and ventilating system, etc. About $25,000. W. N. Blanchard, Pres. C. W. Bates, Natl. Bank Bldg., Wheeling, W. Va.

O., Marietta—The City Light Comn. plans to build a hydro-electric plant for the purpose of furnishing lighting and motive power for this city.

Ind., East Chicago—The Edwards Valve & Mfg. Co., 1200 145th St., plans to build a warehouse including a steam heating system on 145th St. About $450,000. W. T. Branitsky, 64 West Randolph St., Chicago, Ill., Archt.

Ind., Indianapolis — Donald Graham, Archt., 1128 Hume-Mansur Bldg., plans to build a 3 story apartment house including a steam heating system on North Meridian St. About $550,000. Owner's name withheld.

Ind., Indianapolis—The Loyal Order of Moose, Lodge 17, 135 North Delaware St., plans to build a 12 story lodge building. About $375,000. Architect not yet selected.

Ind., Indianapolis—The Masonic Temple Association, Illinois and North Sts., plans to build a 4 story, 100 x 100 ft. addition to its lodge building on North Illinois St. About $750,000. Architect not yet selected.

Ind., Martinsville — The Martinsville Springs Hotel and Sanitarium Co., c/o H. Zeigler Deitz, Archt., 301 Pub. Savings & Trust Bldg., Indianapolis, plans to build a 3 story hotel and sanitarium including a steam heating system, here. About $1,250,000.

Ill., Bellwood—The city, c/o J. A. Fippenger, Pres., is having plans prepared for a water works system including a reservoir, centrifugal pumps, etc. About $167,000. Edgar A. Rossiter, 127 North Dearborn St., Chicago, Engr.

Ill., Flora—The city is having plans prepared for improving the waterworks system and building additions to the electric light and power plant. About $40,000. Fuller & Beard, Chemical Bldg., St. Louis, Mo., Engrs.

Ill., Freeburg—The city will receive bids until June 23 for a power plant. About $25,000. Fuller & Beard, Chemical Bldg., St. Louis, Mo., Engrs.

Ill., Hanover—The town is having plans prepared for a 1 story, 110 x 112 ft. power plant, including centrifugal pumps and Monor steel tank service connection from pipe hydrants, etc. About $30,000. Holland, Ackerman & Holland, 106 East Liberty St., Ann Harbor, Mich., Engrs.

Ill., Waukegan—Lake Co., c/o Conrad Holstein, Comr., 225 Washington St., plans to build a 3 story court house addition including a steam heating system. About $400,000. Architect not yet selected.

Wis., Kewaunee—The city Light & Water Comn. will receive bids until June 21 for one centrifugal pump, etc. About $25,000. James W. Cain, Secy.

Wis., Milwaukee—The Sewerage Comn., City Hall, received bids for the foundation of a power house on Jones Island, from the Dahlman Constr. Co., 456 Bway., $79,670; S. M. Siesel, 105 Wells St., $79 863; E. E. Gillen Co., 128 Wisconsin St., $80,920. Noted May 23.

Ia., Des Moines—The Bd. Educ. is having plans prepared for a 3 story, 170 x 362 ft. high school to be known as the Abraham Lincoln High School including a steam heating system on 9th St. S. W., and Loomis Ave. About $600,000. Proudfoot, Bird & Rawson, 710 Hubbell Bldg., Archts.

Ia., Lytton—The Bd. Educ. received bids for the installation of a heating and forced ventilation system in the proposed 2 story, 62 x 135 ft. school here from Holmberg & Gordon, Sac City, Ia., $10,060. Noted March 9.

Minn., Willmar—The city plans to build and equip a generating plant for electric light and power station. About $45,000.

Kan., Lawrence—The State will receive bids until June 21 for a 2 story power plant, here. About $100,000. J. A. Kimball, Topeka, Bus. Mgr. Ray Gamble, 1415 Fillmore St., Topeka, Archt. Noted May 10.

Neb., Lincoln—The Bd. Educ. will receive bids until July 6, for a 2 story, 120 x 292 ft. grade school on 25th and North Sts. About $400,000. Fiske & McGinnis, Banker Life Bldg., Archts. Walter E. Gilham, Mutual Bldg., Kansas City, Mo., Engr. Noted April 19.

Neb., Pawnee City—The city, c/o H. D. Flory, Clk., will soon award the contract for remodeling the electric power plant here. About $80,000. E. T. Archer & Co., New England Bldg., Kansas City, Mo., Engr.

Neb., West Point—The city, c/o O. E. Meade, Clk., plans to build a 1 story light and power plant. About $58,000. Architect not yet selected.

S. D., Redfield—The city will soon award the contract for a tower and pumping station including centrifugal pumps for new water-works system. About $160,000. Cory & LeCorq, Aberdeen, Engrs.

Mo., Columbia—E. E. Trunnell, Novinger, plans to build a 2 story, 90 x 160 ft. theater on Bway., here. About $600,000. Architect not yet selected.

Okla., Beggs—H. T. Purnell is in the market for motors, gas engines, etc.

Tex., Lampasas—The city is having plans prepared for remodeling its waterworks plant and distribution system. Plans include a pumping station and pumps, etc. J. B. Hawley, Consult. Engr.

Cal., Los Angeles—John C. Austin, Archt., 1125 Baker-Detwiler Bldg., will soon receive bids for a church on 8th and Hope Sts., for the First Methodist Episcopal Church, Trinity Auditorium. About $500,000.

Cal., Los Angeles—Dodd & Richards, Archts., 905 Brack Shops Bldg., are preparing plans for a hotel on Vista Del Mar and Hollywood Blvd. About $2,000,000. Owner's name withheld

CONTRACTS AWARDED

Vt., Stearsburg—The New England Power Co., 35 Harvard St., Worcester, Mass., has awarded the contract for a 1 story power house, earth dam and penstock in connection with hydro-electric plant along the Deerfield River, here, to the Aberthaw Constr. Co., 27 School St., Boston, Mass. About $225,000 Noted May 31.

Mass., Lawrence—The American Woolen Co. has awarded the contract for a 2 story, 80 x 120 ft. power house, here, to the Turner Constr. Co., 78 Tremont St., Boston. About $125,000.

N. Y., New York (Brooklyn Boro.)—The Bd. Educ., 500 Park Ave., has awarded the contract for a school on Sandford St. between Willoughby and De Kalb Aves., to T. A. Clarke Co., 12 Livingston St., at $712,300.

N. Y., New York (Brooklyn Boro.)—Levy Bros., 189 Montague St., will build a 130 x 184 ft. theater on Bedford Ave. and Lincoln Pl. About $750,000. Work will be done by day labor.

N. Y., New York (Manhattan Boro)—Acker, Merrall & Condit, 255 5th Ave., has awarded the contract for a 12 story, 50 x 90 ft. office building at 343 Madison Ave., to J. G. Siegel, 17 East 49th St. About $500,000.

N. Y., New York (Manhattan Boro)—The Natl. Surety Co., 115 Bway., will build an 8 story, 115 x 135 ft. office building at 123 Washington St. About $500,000. Work will be done by separate contracts.

Pa., Pittsburgh—The Oliver Iron & Steel Co., 10th and Muriel Sts., has awarded the contract for the substructure of a boiler house on South Side, to D. T. Riffle, 1006 Forbes St. Cost, between $35,000 and $40,000. Noted April 19.

S. C., Charleston — The Francis Marion Hotel Co. has awarded the contract for a 12 story hotel, to G. A. Fuller Co., 949 Bway., New York City. About $1,000,000.

O., Ashtabula — The Bd. Educ. has awarded the contract for the installation of steam heating system in the proposed 2 story school on State St., to the Huffman-Wolf Co., 666 North High St., Columbus, at $27,848.

O., West Park—The Bd. Educ., 14574 Lorain Ave., has awarded the contract for the installation of a steam heating system in the proposed 3 story, 75 x 216 ft. school on West 125th St., here, to the J. Roemer Heating Co., East 20th St., Cleveland, at $43,500. Noted May 10.

Ill., Chicago—The Chicago Lutheran Hospital Association, 155 North Clark St., will build a 6 story, 100 x 146 ft. hospital including a steam heating system on Kedzie Ave. and Haddon St. About $400,000. Work will be done by day labor.

Wis., Madison — The Madison General Hospital Association, 12 South Carroll St., has awarded the contract for an addition to hospital and power house, to Morgan & Morgan, at $80,000.

Wis., Sauk City—The village has awarded the contract for the installation of a water-works system including a one 2-stage 250 g.p.m., centrifugal type, electrically driven pump, to Arthur A. Luebke, 706 9th St., Watertown, Wis., at $34,500. Noted May 23.

Minn., St. Cloud—Stearns Co. Bd. has awarded the contract for a 2 story, 43 x 90 ft. jail and sheriff's residence including boiler room, to E. Hirt & Son, at $63,018.

Que., Montreal—The Canada Cement Co. has awarded the contract for a 12 story, 120 x 165 ft. office building on Cathcart St., to G. A. Fuller, Beaver Hall Hill. About $2,000,000.

Que., Montreal—The Canada Cement Co., Herald Bldg., has awarded the contract for a 10 story, 120 x 165 ft. office building including a steam heating system on Philips Pl., to G. A. Fuller & Co., 285 Beaver Hall Hill, at $1,250,000.

Que., Montreal—The Beaver Bldg. Co., 65 Victoria St., will build a 10 story, 128 x 146 ft. office building, including a low pressure or vapor steam heating system. About $2,000,000. Work will be done by day labor.

Ont., Scarboro—The town has awarded the contract for centrifugal pumps, to the Canadian Allis-Chalmers, 212 King St., West, Toronto, triplicate pumps, to Goldie & McCulloch, Traders Bank Bldg., Toronto, and filtration plant, to the Central Foundation Co., 14 Wellington St., East Toronto.

Opportunity Advertising

SEARCHLIGHT SECTION

PAGES 62 to 67 ***PAGES 62 to 67***

PRICES - MATERIALS - SUPPLIES

Electrical prices on following page are prices to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.

POWER-PLANT SUPPLIES

HOSE—

	Fire
Underwriters' 2½-in.	55c. per ft.
Common, 2½-in.	60%

	Air		
	First Grade	Second Grade	Third Grade
¼-in. per ft.	$0.35	$0.25	$0.16

Steam—Discounts from List

First grade	40–10%	Second grade	50–5%	Third grade	60–5%

RUBBER BELTING—The following discounts from list apply to transmission rubber and duck belting:

Competition	65-10%	Best grade	50-10%
Standard	60-10%		

LEATHER BELTING—Present discounts from list in fair quantities (½ doz. rolls):

Light Grade	Medium Grade	Heavy Grade
45%	30–10–5%	30–5%

RAWHIDE LACING { For cut, best grade, 50–10%, 2nd grade, 60%.
For laces in sides, best, 41c per sq. ft.; 2nd, 39c.
Semi-tanned: cut, 50%; sides, 43c per sq. ft.

PACKING—Prices per pound:

Rubber and duck for low-pressure steam	$1.00
Asbestos for high-pressure steam	2.00
Duck and rubber for piston packing	1.00
Flax, regular	1.20
Flax, waterproofed	1.70
Compressed asbestos sheet	1.00
Wire insertion asbestos sheet	1.50
Rubber sheet	.45
Rubber sheet, wire insertion	.70
Rubber sheet, duck insertion	.50
Rubber sheet, cloth insertion	.30
Asbestos packing, twisted or braided and graphited, for valve stems and stuffing boxes	1.50
Asbestos wick, ½- and 1-lb. balls	.85

PIPE AND BOILER COVERING—Below are part of standard lists, with discounts.

PIPE COVERING		BLOCKS AND SHEETS	
Pipe Size	Standard List Per Lin.Ft.	Thickness	Price per Sq.Ft.
1-in.	$0.27	½-in.	$0.27
2-in.	.36	1 -in.	.30
6-in.	.80	1½-in.	.45
4-in.	.60	2 -in.	.60
3-in.	.45	2½-in.	.75
8-in.	1.10	3 -in.	.90
10-in.	1.30	3½-in.	1.05

85% magnesia high pressure ..... 25% off

For low-pressure heating and return lines { 4-ply ..... 50% off
3-ply ..... 52% off
2-ply ..... 54% off

PORTLAND CEMENT—New York, $2.80 without bags, in cargo lots delivered on job. Bag charge of 40c. per bbl.

STRUCTURAL STEEL—New York delivered price, 3 to 15-in. beams and channels and 3 to 6-in. angles, tees, and plates, all $3.33 per 100 lb.

COTTON WASTE—The following prices are in cents per pound:

	New York			
	Current		Cleveland	Chicago
White	9.00@12.00		12.50	14.25
Colored mixed	6.50@ 9.50		9.00	12.00

WIPING CLOTHS—Jobbers' price per 1000 is as follows:

	13½ x 13½	13½ x 20½
Cleveland	$55.00	$65.00
Chicago	41.00	43.50

LINSEED OIL—These prices are per gallon:

	New York	Cleveland	Chicago
Raw in barrels (5 bbl. lots)	$0.80	$0.75	$0.89
5 gal. cans	.83*	.85	1.14

*Charge of $2.25 for two cans.

WHITE AND RED LEAD—Base price per pound:

	Red				White	
	Current		1 Year Ago		Current	1 Yr. Ago
	Dry	In Oil	Dry	In Oil	Dry and In Oil	Dry and In Oil
100-lb. keg	13.00	14.50	15.00	16.50	13.00	15.00
25- and 50-lb. kegs	13.25	14.75	15.25	16.75	13.25	15.25
12½-lb. keg	13.50	15.00	15.50	17.00	13.50	15.50
1-lb. cans	16.00	17.50	17.50	18.50	16.00	17.00
5-lb. cans	18.00	19.50	19.50	19.50	18.00	18.00

500 lb. lots less 10% discount; 2000 lb. lots less 10–2½%.

RIVETS—The following quotations are allowed for fair-sized orders from warehouse:

	New York	Cleveland	Chicago
Steel ½ and smaller	50%	60%	45%
Tinned	45%	60%	30%

Structural rivets, ¾, ⅞, 1 in. diameter by 2 in. to 5 in. sell as follows per 100 lb.:

New York	$4.65	Chicago	$4.88	Pittsburgh	$3.70

Boiler rivets, same sizes:

New York	$4.75	Chicago	$4.98	Pittsburgh	$3.80

REFRACTORIES—Prices in carlots:

Chrome brick, eastern Shipping points	net ton	70@ 80
Chrome cement, 40@45% Cr_2O_3	net ton	40@ 45
Chrome cement, 40@45% Cr_2O_3, in sacks	net ton	44@ 49
Clay brick, 1st quality, fire clay, 9-in. shapes, Pennsylvania, Ohio and Kentucky	per 1000	55@ 60
Clay brick, 2d quality, fire clay, 9-in. shapes Pennsylvania, Ohio and Kentucky	per 1000	45@ 50
Magnesite brick: 9-in. straight	net ton	80@ 90
Magnesite brick: 9-in. arches, wedges and keys	net ton	88@ 98
Magnesite brick: Soaps and splits	net ton	112@ 128
Silica brick: Chicago district	per 1000	55@ 60
Silica brick: Birmingham, Ala.	per 1000	46@ 51
Silica brick: Mt. Union, Pa.	per 1000	45@ 50
Magnesite cement: Eastern shipping point, in bags	net ton	59@ 64
Magnesite cement: Eastern shipping point, in bags	net ton	55@ 60

BABBITT METAL—Warehouse prices in cents per pound:

	New York	Cleveland	Chicago
Best grade	70.00	43.50	35.00
Commercial	30.00	15.50	9.00

COLD FINISHED STEEL—Warehouse prices are as follows:

	New York	Chicago	Cleveland
Round shafting or screw stock, per 100 lb. base	$4.73	$4.63	$4.25
Flats, square and hexagons, per 100 lb. base	5.23	4.63	4.75

BOILER SPECIALTIES—F. o. b. New York or Jersey City, discounts on list:

	Current
Copper ferrules	70%
Boiler flanges	50%
Boiler lugs	Net list
Boiler stay bolts	60%
Boiler patch bolts	Net list
Boiler fitting-up bolts	45%
Pressed steel boiler lugs	Net list
Pressed steel boiler hangers	Net list

WROUGHT PIPE—The following discounts are to jobbers for carload lots on the Pittsburgh basing card of April 13, 1921:

BUTT WELD

Steel			Iron		
Inches	Black	Galv.	Inches	Black	Galv.
1 to 3	62½	50	⅜	33½	18½
			1 to 1½	35½	20½

LAP WELD

2	54½	58½	15	42½	...
2½ to 6	58½	46	2	30½	16½
7 to 12	54½	41	2½ to 6	33½	20½
13 and 14	45	...	7 to 12	29½	16½

BUTT WELD, EXTRA STRONG, PLAIN ENDS

1 to 1½	60½	49	⅜ to 1½	35½	21½
2 to 3	61½	50			

LAP WELD, EXTRA STRONG, PLAIN ENDS

2	52½	41	2	31½	18½
2½ to 4	56½	45	2½ to 4	34½	22½
4½ to 6	55½	44	4½ to 6	33½	21½
7 to 8	50½	37	7 to 8	24½	12½
9 to 12	45½	32	9 to 12	19½	7½

BOILER TUBES—Following are prices in New York warehouse of tubes manufactured according to specifications of the American Society of Mechanical Engineers:

Size	Lapweld Steel	C. C. Iron	Seamless Steel
1	.....	.....	$0.27
1¼	.....	.....	.26
1½	.....	.....	.24
1¾	$0.2200	$0.3255	.26
2	.2100	.2834	.25
2¼	.2400	.3176	.29
2½	.2910	.3814	.36
2¾	.3298	.4323	.39
3	.3686	.4781	.43
3¼	.4365	.5663	.51
3½	.4032	.5728	.55
4	.5124	.70	.72

Tubes 2¼ in. diameter, or smaller, over 18 ft. long, 10 per cent extra.

These prices are net per lineal foot based on stock lengths. If cut to special lengths, billing will be based on the entire stock lengths.

In addition to the above, standard cutting charges are as follows:

1¼ in. to 2 in. diameter, 5c. per cut. 2½ in. diameter, 7c. per cut
2¾ in. diameter, 6c. per cut. 3 in. diameter, 9c. per cut
3½ in. to 4 in. diameter, 10c.

ELECTRICAL SUPPLIES

ARMORED CABLE—

B. & S. Size	Two Cond. M Ft.	Three Cond. M Ft.	Two Cond. Lead M Ft.	Three Cond. Lead M Ft.
No. 14 solid	$ 60.00(net)	$138.00	$164.00	$210.00
No. 12 solid	135.00	170.00	225.00	265.00
No. 10 solid	185.00	235.00	275.00	325.00
No. 8 stranded	285.00	375.00	520.00	500.00
No. 6 stranded	400.00	500.00	560.00	.....

From the above lists discounts are:

Less than coil lots	10%	5%
Coils to 1,000 ft.	20%	15%
1,000 ft. and over	30%	20%

BATTERIES, DRY—Regular No. 6 size red seal, Columbia, or Ever-Ready:

	Each, Net
Less than 12	$0.48
12 to 50	.41
50 to 125 (bbl.)	.38
125 (bbl.) or over	.35

CONDUIT, Price per 1,000 ft.; ELBOWS AND COUPLINGS, Per 100 pieces, f. o. b. New York, with 10-day discount of 5 per cent.

	Conduit		Elbows		Couplings	
Size, In.	Black 2,500 to 5,000 Lbs.	Galvanized 2,500 to 5,000 Lbs.	Black 2,500 to 5,000 Lbs.	Galvanized 2,500 to 5,000 Lbs.	Black 2,500 to 5,000 Lbs.	Galvanized 2,500 to 5,000 Lbs.
¼	$71.40	$76.50	$16.91	$18.01	$6.23	$6.65
⅜	94.00	100.00	22.25	23.75	8.90	9.50
½	134.30	144.50	32.93	35.15	11.57	12.35
¾	181.70	195.50	42.75	45.00	16.15	17.00
1	217.20	233.70	57.00	60.00	19.95	21.00
1¼	292.30	314.50	104.50	110.00	26.60	28.00
1½	462.10	497.30	171.00	180.00	38.00	40.00
2	604.30	65.00	456.00	480.00	57.00	60.00
2½	754.40	818.80	1,007.00	1,060.00	76.00	80.00
3	910.00	980.00	1,163.75	1,225.00	95.00	100.00

CONDUIT NON-METALLIC, LOOM—

Size I. D., In.	Feet per Coil	List, Ft.
⅜	250	$0.05½
½	250	.06
⅝	250	.09
¾	200	.12
⅞	200	.15
1	150	.18
1¼	100	.25
1½	100	.33
1¾	Odd lengths	.40
2	Odd lengths	.55

1000 ft. and over.... 55%
Coils..... 45%
Less coils, 35%

CUT-OUTS—Following are net prices each in standard-package quantities:

CUT-OUTS, PLUG

S. P. M. L.	$0.12	D. P. D. B.	$0.43
D. P. M. L.	.21	T. P. to D. P. S. B.	.26
T. P. M. L.	.33	T. P. S. B.	.38
D. P. S. B.	.23	T. P. D. B.	.64

CUT-OUTS, N. E. C. FUSE

	0-30 Amp.	31-60 Amp.	60-100 Amp.
D. P. M. L.	$0.50	$1.30	$1.68
T. P. M. L.	.70	1.70	2.40
D. P. S. B.	.63	1.60	.....
T. P. S. B.	1.15	2.40	.....
D. P. D. B.	1.10	3.00	.....
T. P. D. B.	1.90	5.40	.....
T. P. to D. P. D. B.	1.30	3.80	.....

FLEXIBLE CORD—Price per 1,000 ft. in coils of 250 ft.:

No. 18 cotton twisted	$15.40
No. 16 cotton twisted	18.00
No. 18 cotton parallel	18.40
No. 16 cotton parallel	21.50
No. 18 cotton reinforced heavy	25.00
No. 16 cotton reinforced heavy	29.00
No. 18 cotton reinforced light	23.50
No. 16 cotton reinforced light	27.50
No. 18 cotton Canvasite cord	18.50
No. 16 cotton Canvasite cord	25.75

FUSES, ENCLOSED—

250-Volt	Std. Pkg.	List	600-Volt	Std. Pkg.	List
3-amp. to 30-amp.,	100	$0.25	3-amp. to 30-amp.,	100	$0.40
35-amp. to 60-amp.,	100	035	35-amp. to 60-amp.,	100	.60
65-amp. to 100-amp.,	50	.90	65-amp. to 100-amp.,	50	1.50
110-amp. to 200-amp.,	25	2.00	110-amp. to 200-amp.,	25	2.50
225-amp. to 400-amp.,	25	3.60	225-amp. to 400-amp.,	25	5.50
425-amp. to 600-amp.,	10	5.50	450-amp. to 600-amp.,	10	8.00

Discount: Less 1-5th standard package, 40%; 1-5th to standard package, 45%; standard package, 50%.

RENEWABLE FUSES, ENCLOSED—

Sizes	250-Volt List-Price	600-Volt List-Price	Std. Pkg. Quantity	Carton Quantity
1 to 30-amp.	$0.50 ea.	$1.10 ea.	100	10
35 to 60-amp.	1.00 ea.	1.25 ea.	100	10
65 to 100-amp.	2.00 ea.	3.00 ea.	50	5
110 to 200-amp.	4.00 ea.	5.00 ea.	25	5
225 to 400-amp.	7.50 ea.	11.00 ea.	25	1
450 to 600-amp.	11.00 ea.	16.00 ea.	10	1
450 to 600-amp.	11.00 ea.	16.00 ea.	10	1

RENEWAL LINE FOR ABOVE FUSES—

1 to 30	$0.30 ea.	$0.05	100	100
35 to 60	.05 ea.	.06	100	100
65 to 100	.10 ea.	.10	50	50
110 to 200	.15 ea.	.15	25	50
225 to 400	.30 ea.	.30	25	25
450 to 600	.60 ea.	.60	10	10

Discount Without Contract—Fuses:	
Broken carton	5%
Unbroken carton but less than std. pkg.	22%
Std. pkg.	40%
Discount Without Contract—Renewals:	
Less than std. pkg.	Net list
Standard package	40%
Discount With Contract—Fuses:	
Broken cartons	10%
Unbroken cartons but less than standard package	26%
Standard package	42%
Discount With Contract—Renewals:	
Less standard package	Net list
Standard package	42%

FUSE PLUGS, MICA CAP—

0-30 ampere, standard package	$4.75C
0-30 ampere, less than standard package	5.25C

LAMPS—Below are present quotations in less than standard package quantities:

Straight-Side Bulbs — Mazda B— Watts	Plain	Frosted	No. in Package	Pear-Shaped Bulbs — Mazda C— Watts	Clear	Frosted	No. in Package
10	$0.40	$0.45	100	75	$0.75	$0.80	50
15	.40	.45	100	100	1.10	1.25	24
25	.40	.45	100	150	1.55	1.70	24
40	.40	.45	100	200	2.10	2.30	24
50	.40	.45	100	300	3.15	3.40	24
60	.45	.50	100				12
				500	4.60	4.90	12
				750	6.50	6.90	8
				1,000	7.50	7.95	8

Standard quantities are subject to discount of 10% from list. Annual contracts ranging from $150 to $300,000 net allow a discount of 17 to 40% from list.

PLUGS, ATTACHMENT—

	Each
Porcelain separable attachment plug	$0.28
Composition 2-piece attachment plug	.36
Swivel attachment plug	.20
Current taps	.45

RUBBER-COVERED COPPER WIRE—Per 1000 ft. f. o. b. New York.

No.	Solid Single Braid	Solid Double Braid	Stranded, Double Braid	Duplex
14	$ 6.75	$ 8.90	$10.00	$16.50
12	9.00	10.75	13.00	21.30
10	11.50	14.10	16.25	27.30
8	16.00	18.50	21.50	35.90
6	.....	.....	32.00	.....
4	.....	.....	43.05	.....
2	.....	.....	63.00	.....
1	.....	.....	86.00	.....
0	.....	.....	99.70	.....
00	.....	.....	119.50	.....
000	.....	.....	144.50	.....
0000	.....	.....	171.00	.....

SOCKETS, BRASS SHELL—

½ In. or Pendant Cap — Key Each	Keyless Each	Pull Each	¾ In. Cap — Key Each	Keyless Each	Pull Each
$0.33	$0.30	$0.60	$0.39	$0.36	$0.66

Less 1-5th standard package	+50%
1-5th to standard package	+20%
Standard package	—15%

WIRE, ANNUNCIATOR AND DAMPPROOF OFFICE—

No. 18 B. & S. regular spools (approx. 8 lb.)	42c. lb.
No. 18 B. & S. regular 1-lb. coils	43c. lb.

WIRING SUPPLIES—

Friction tape, ¾ in., less 100 lb. 48c. lb., 100 lb. lots	44c. lb.
Rubber tape, ¾ in., less 100 lb. 50c. lb., 100 lb. lots	45c. lb.
Wire solder, less 100 lb. 40c. lb., 100 lb. lots	36c. lb.
Soldering paste, 2 oz. cans	$1.50 doz.

SWITCHES, KNIFE—

TYPE "C" NOT FUSIBLE

Size, Amp.	Single Pole, Each	Double Pole, Each	Three Pole, Each	Four Pole, Each
30	$0.42	$0.68	$1.02	$1.36
60	.74	1.22	1.84	2.44
100	1.50	2.50	3.76	5.00
200	2.70	4.50	6.76	9.00

TYPE "C" FUSIBLE, TOP OR BOTTOM

30	70	1.06	1.60	2.12
60	1.18	1.80	2.70	3.60
100	2.38	3.66	5.50	7.30
200	4.40	6.76	10.14	13.50

Discounts:	
Less than $10.00 list value	15%
$10 to $25 list value	net list
$25 to $50 list value	5%
$50 to $200 list value	20%
$200 list value or over	25%